ASTRONOMY

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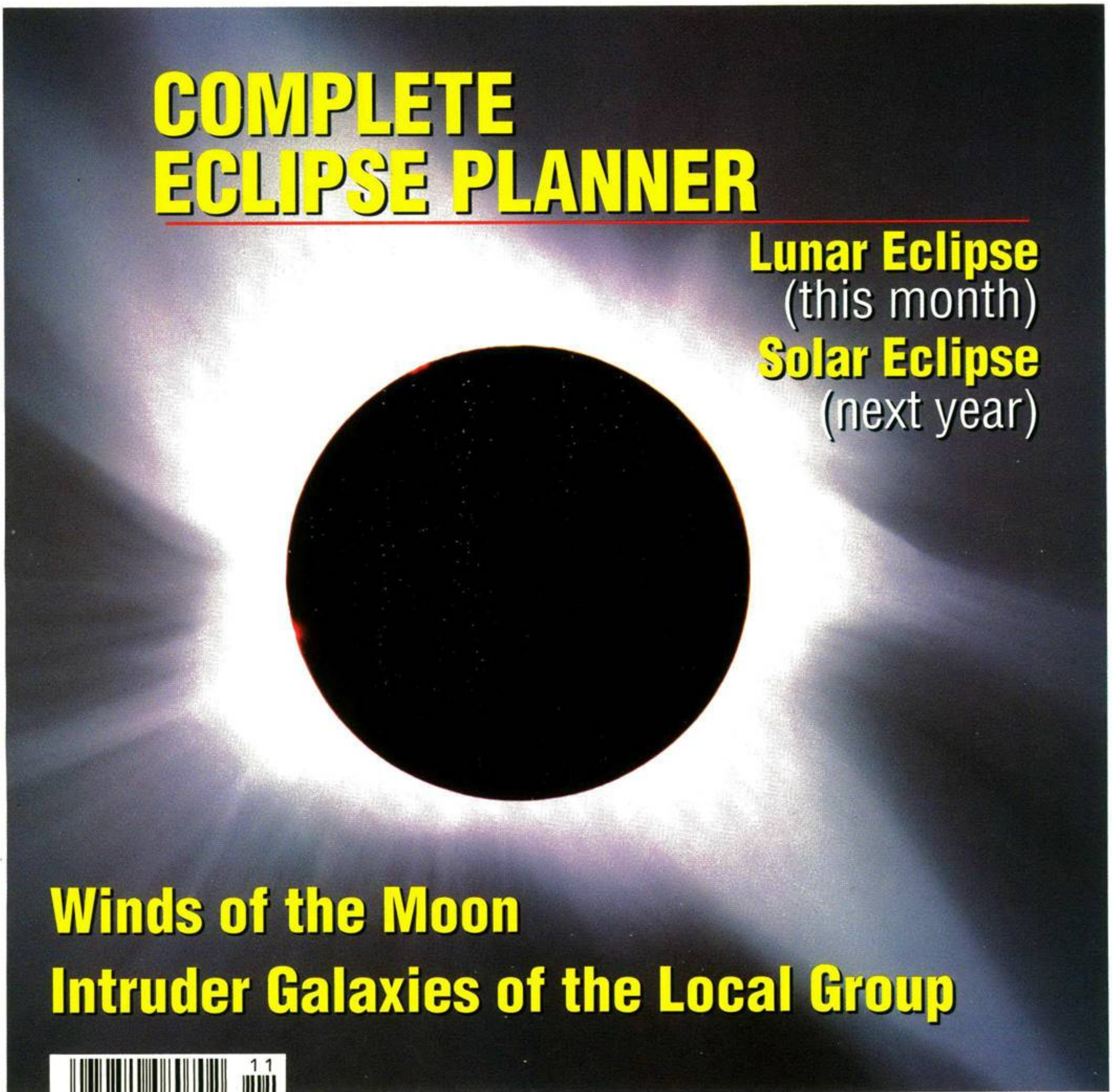
1994 TELESCOPE BUYER'S GUIDE

Getting the RIGHT Scope for You



COMPLETE ECLIPSE PLANNER

Lunar Eclipse
(this month)
Solar Eclipse
(next year)

Winds of the Moon

Intruder Galaxies of the Local Group

- Explore Our Galaxy's Neighbors
- Giotto Spacecraft Visits Second Comet

MEADE
MEADE LX200
Meade 8X50
File
Display
Options
Tools
Input
Label
Lines
Telescope
Help
Meade AstroSearch - 10:32 PM 8/16/93
M23
M21
M20
M8
M28
M22
Sagittarius
M54
M70
M69
M6
M7
LX200
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Find
Cntr
Guide
Close
Z-NOTE 325Lx
MEADE LX200
SMART DRIVE
Meade
ENTER
MODE
GO TO
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ALT
SLEW 7
RET 8
M 9
FIND 4
FOCUS 5
STAR 6
CNTR 1
MAP 2
CNGC 3
GUIDE 0
PREV
NEXT

Full PC-Interface Capability with your Meade® 8", 10" or 12" LX200 Schmidt-Cassegrain.

Use Meade AstroSearch/200 sky software to point-and-click on any of 45,000 objects.

Simulated LX200 keypad permits telescope slewing directly from the PC display, at any selected slew rate.

Meade 8" LX200

PC APPLICATIONS WITH MEADE LX200 SCHMIDT-CASSEGRAINS AND *ED* APOCHROMATIC REFRACTORS

Meade® AstroSearch/200™ sky software permits point-and-click, *fully remote* automatic telescope positioning to 45,000 objects.

One of the easiest and most enjoyable applications of Meade 8", 10" and 12" LX200 Schmidt-Cassegrains (or Meade CDS-driven *ED* Apochromatic Refractors) is the interface of a common desktop or laptop Personal Computer* (PC) to the telescope. It's this easy:

- Connect your PC to the LX200, using the PC port located on the LX200's power panel.
- Load Meade AstroSearch/200 sky software into your PC.

Equipped in this way, the LX200 becomes a powerful, PC-driven observing tool:

- Using the PC's mouse, just point-and-click on any of the 45,000 planetary, deep-space, or stellar objects now visible on the PC display, and watch as the LX200's powerful, high-torque control motors **automatically** move ("slew") the telescope at up to 8° per second on both axes, *precisely centering the object in the telescopic field.*

Remarkable applications as the above are made possible by the advanced technology built, as standard equipment, into every Meade 8", 10", and 12" LX200 telescope. Technology that far surpasses any other commercial telescope. Technology that has made these the largest-selling serious telescopes in the world.

*For safety reasons AC-powered personal computers should be used indoors only.

Meade 8", 10" and 12" LX200 SCT's (and #1697 CDS-driven ED Apochromatic Refractors) include an RS-232 serial port (PC connector) on the power panel.

Current (mA x 100)
MEADE LX200
COMPUTER DRIVE SYSTEM
LX QUARTZ - DC SERVO MOTOR
SMART DRIVE
On
Off
N
S
Encoders
RS232
Focuser
Reticle
Keypad
Power 12 vDC
CCD

Meade AstroSearch/200 sky software includes an extremely wide range of additional capabilities:

- **Point-and-click onto obscure, difficult-to-find objects**, including deep-space nebulae and galaxies as faint as 15th magnitude.
- **Print out your own star charts**—charts more detailed than any available in books. Zoom-in on the display and print out, at high resolution, small sky regions of particular interest.
- **Use the simulated LX200 hand controller** on the PC display for remote control of the telescope.

The Meade AstroSearch/200 celestial software package, supplied on 3.5" discs for Windows™ 3.1 or higher, is available from Meade dealers at $99.95**. Each package includes an 8 ft. PC-to-LX200 connection cable and an instruction manual with applications for Meade LX200 SCT's and *ED* Apochromatic Refractors.

Important new features now included as standard equipment with Meade 8", 10" and 12" LX200 Schmidt-Cassegrains!

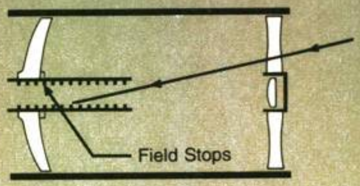
Every 8", 10" and 12" LX200 now shipped from the Meade Irvine, Calif., factory includes important new features that put these instruments even further into the forefront of modern astronomy:

- **2-Star Alignment without Tripod Leveling!** Quick-align the LX200 *in seconds* in the altazimuth mode without knowing your latitude or longitude, without even leveling the tripod! Just use 2 easy-to-find reference stars, and the telescope points and tracks with uncanny accuracy.
- **Two New Optional Object Databases:** Included with every LX200 is a basic 747-object database of the finest deep-space objects, reference stars, and the 8 major planets. New Meade *Version 3.20* LX200 software allows for two new optional object libraries:

—***Library Option 1:*** An object database of ***10,600 celestial objects*** taken from the Messier, NGC, and IC catalogs. Available at $99.**

—***Library Option 2:*** An object database of ***64,350 celestial objects,*** including the 10,600 objects of Library Option 1, above. Available at $149.**

- **Contrast-Enhancing Field-Stops—another Meade *first:*** All Meade 8", 10", and 12" SCT's now include a series of computer-optimized internal field stops, for greater rejection of unwanted stray light than ever before possible. These field stops, machined into the inside-diameter surface of the primary-mirror baffle tube *(see diagram)*, significantly increase lunar, planetary, and deep-space image contrast, compared to SCT's not so equipped.



Field-stops *(arrow)*, now included on Meade 8", 10" and 12" Schmidt-Cassegrains, significantly increase image contrast by effectively blocking off-axis stray light rays, λ.

Specifications: 8", 10" and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 SC optical tube assembly with super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm-gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; keypad handheld controller with digital readout display, PPEC Smart Drive, four-speed drive control on both axes, GO TO controller, and 747-object software library; 25 ft. power cord and adapter for telescope operation from 115v. AC (DC capability for operation from auto cigarette lighter plug available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); foam-fitted carrying case (8", 10") or foam-fitted thick-wall shipping carton (12"); complete operating instructions.

Supplied complete per catalog specifications**:

8" LX200 Schmidt-Cassegrain	**$2295.**
Equatorial Wedge 8"	**110.**
10" LX200 Schmidt-Cassegrain	**2895.**
12" LX200 Schmidt-Cassegrain	**3995.**
Superwedge 10"/12"	**395.**

Packing & shipping in 48 states: 8"–$105; 10"–$145; 12"-$215.

- **All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.
- For dealer or catalog information see the Meade **Starfinder Reflecting Telescope** ad in this issue.

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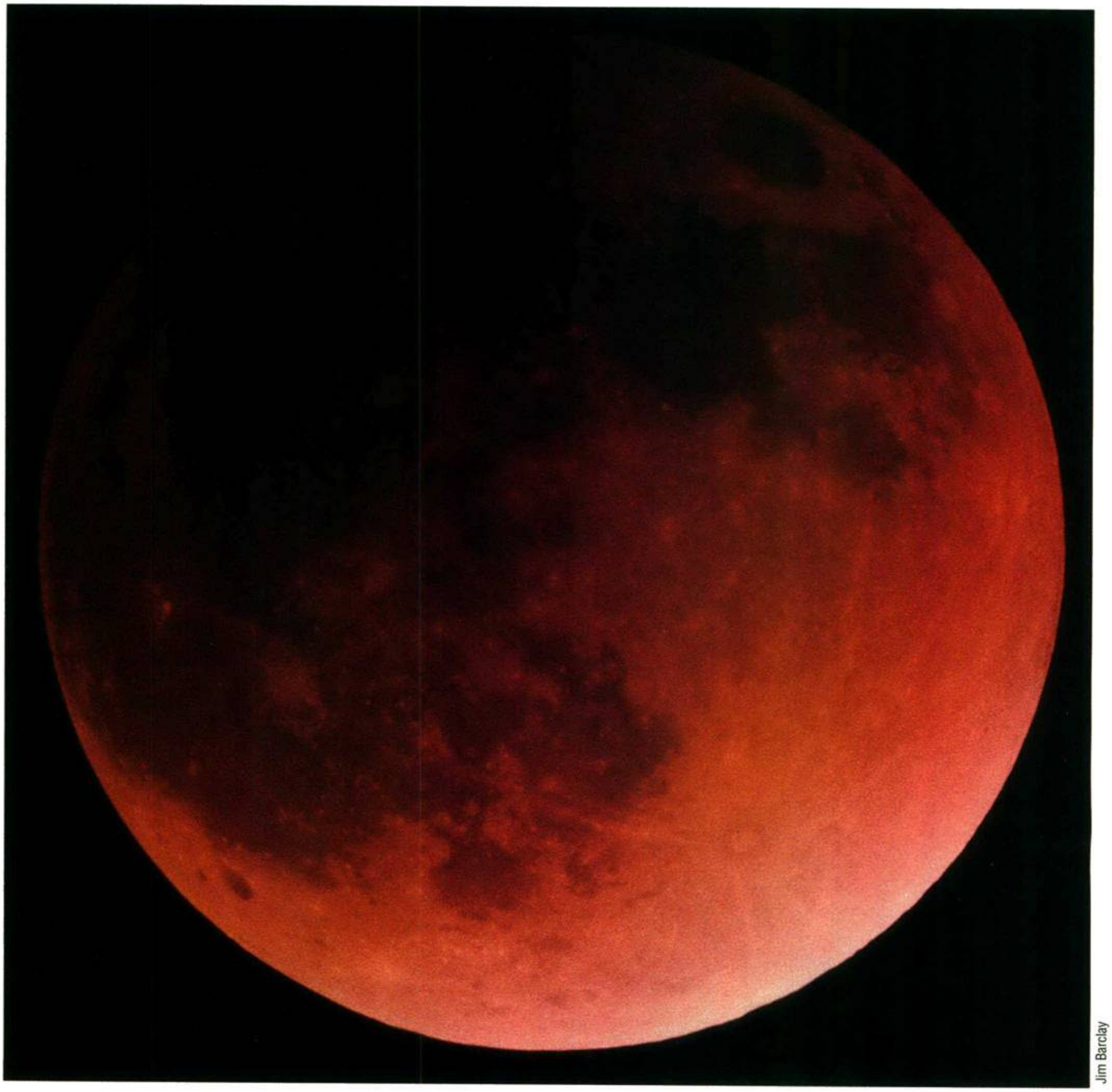
ON THE COVER: People will travel thousands of miles to see the Sun's pearl-white corona during the few moments of totality. To learn where in South America the weather will most likely cooperate during the November 1994 solar eclipse, turn to page 88. Photo by Roland Christen.



Jim Barclay

A BRIGHT ORANGE MOON hung in the sky over Australia during the April 1986 total lunar eclipse. What shade of red will the Moon appear during this November's eclipse? That's anyone's guess, but you'll be prepared for any eventuality after reading our eclipse primer on page 82.

20th ANNIVERSARY YEAR

ASTRONOMY

November 1993

Vol. 21, No. 11

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Five billion years ago the Andromeda Galaxy flung two galaxies out of the Local Group and swallowed two others. By Ken Croswell.

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Air? On the Moon? Though there's not much of it, the Moon's atmosphere may help solve some nagging lunar mysteries. By Alan Stern.

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In 1986 Giotto made headlines at Comet Halley. Last year it garnered less hype but more data as it flew past Comet Grigg-Skjellerup. By Peter Bond.

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The Audit Bureau

Behind the Scenes

BUYING A TELESCOPE

For many people, buying a telescope is the defining act of becoming an amateur astronomer.

You know how it goes. You learn all the constellations visible from your latitude. You make low-power sweeps with binoculars along the Milky Way (and glory in the starfields you find there). You count meteors deep into the wee hours, while dew wets the blanket wrapped around you. You stand in the frosty dawn to spy Venus and the crescent Moon rising together through the trees.

Isn't all this enough to make you feel like a real amateur astronomer?

No, the little voice inside you says. *Not if I don't have a telescope, too . . .*

Well, whatever a telescope's symbolic value, you do need one to explore the full richness of what the universe has to show. Binoculars can give you unforgettable views of the sky — the Milky Way, for instance, or a bright comet and its gossamer tail. But most celestial objects demand more magnification and light-gathering power than binoculars provide.

So I invite you to turn to the center of this issue where you'll find our "1994 Telescope Buyer's Guide." Whether you're a first-time buyer or a seasoned pro, you'll find its handy advice and detailed tables are just the thing to help you sort through the hundreds of makes and models on the market.

If you're a beginner, it can be pretty overwhelming. I suggest you start by giving some thought to what you want out of astronomy. Telescopes are wonderful — they can show you anything in the sky — but each has an area where it excels. The introduction by Associate Editor Alan Dyer will guide you through the maze of choices.

What kind of telescope should you get? You must answer that for yourself. But whatever you get, I urge you to buy quality. Buy the best telescope you can possibly afford and if you can, try to stretch the budget a little.

The reason is that a better-quality telescope is a double bargain. First, you'll have more fun with it. A better scope lets you see things more clearly with less effort, and it is easier to use. It's true a poor instrument will always show you something, but the views won't be as satisfying. The heavens are sending some wonderful sights your way — why throw them away by viewing through a poor instrument?

The second reason is slightly more practical. A good telescope lasts forever, at least with proper care. And because it will never wear out, its resale value will remain high, provided it was well made to begin with. This can be important if you decide to trade it in on a different instrument — or even if you decide astronomy isn't for you.

Buying a telescope may not make you a real amateur astronomer — that kind of thing lies more in your attitude than anything else. But it *is* an open ticket to the universe that you can use every night of your life.

Sincerely,

Robert Burnham

Robert Burnham
Editor

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Letters

LDEF's Striking Space Story

I enjoyed Thomas Brophy's article "Motes in the Solar System's Eye" (May 1993). The photo of a 50-micron particle that struck the Long Duration Exposure Facility (LDEF) with its caption, "Zap! — You're history," brought to mind another collision that occurred 65 million years ago.

Scientists believe a meteorite five to ten miles across smashed into Earth and caused, among other things, the extinction of the dinosaurs. Traveling through the solar system at 70,000 miles per hour, the object hit with the explosive force of 100 megatons of TNT and, at ground zero, produced temperatures hotter than the Sun's. The intense heat spread fires that produced dust, soot, and ash suspended in thick clouds. Sunlight fell to the brightness of full moonlight on present-day Earth, and global winter ensued.

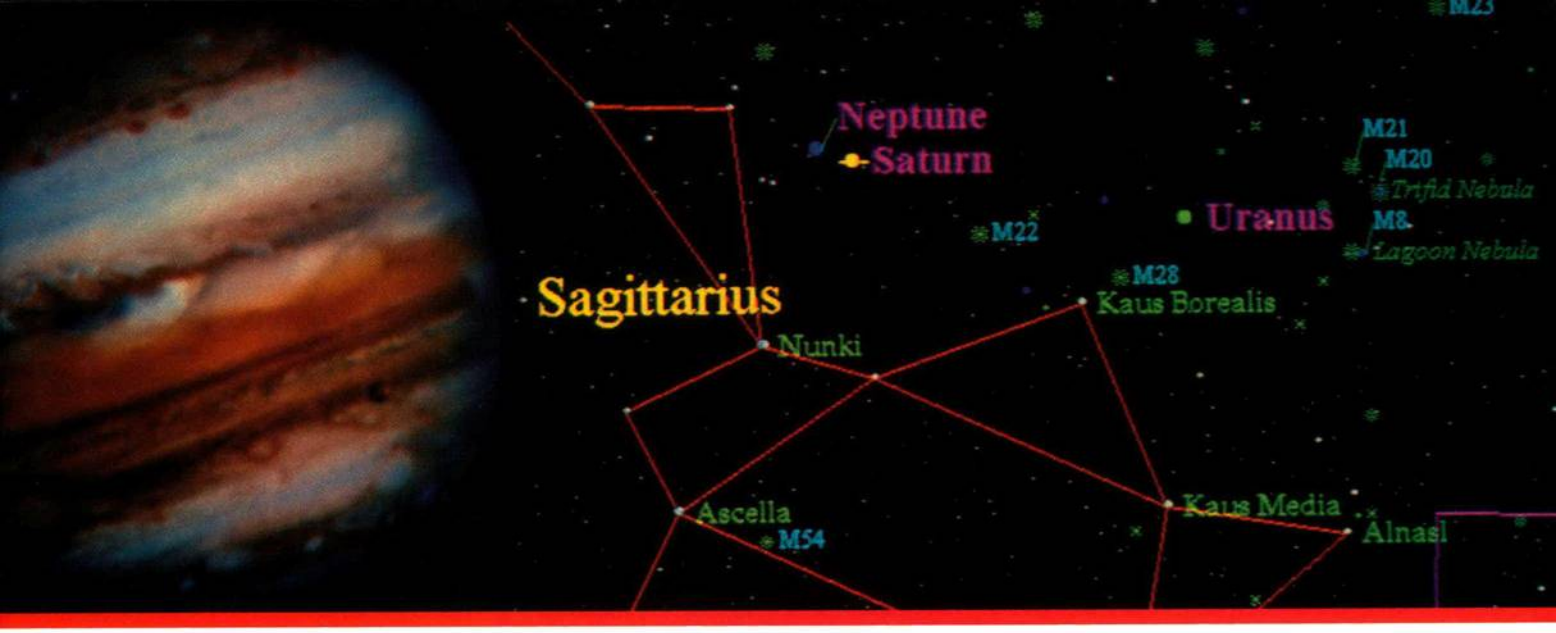
Supposedly a large meteorite will strike Earth every 26 million years on average and could cause other extinctions. What are the chances of huge Earth-crossing asteroids' striking Earth again and, assuming we had sufficient warning, what could we do about it? — *Thomas M. Callahan, Staten Island, New York*

— The best thing would be to use nuclear explosions to slow the object (or speed it up) a little so that it missed Earth. But this would require us to discover the object at least one orbit before impact.

As a first step, NASA has plans to conduct a survey called Spaceguard to discover and track all asteroids and comets with diameters of 1 kilometer or more. The hurdle may be funding: Spaceguard calls for building six 2.5-meter telescopes dedicated solely to the search. The estimated cost is $50 million to set up the program (including building the telescopes) and some $10 million a year to run it. See the related story "Death from the Sky" by Christopher Chyba in next month's ASTRONOMY.

Holy black holes! Brophy missed the mark when he stated LDEF "orbited Earth with the sole purpose of being struck by meteoroids and cosmic debris." Built by NASA's Langley Research Center, LDEF carried only eight projects (out of 57 in all) dedicated to micrometeoroid-related strikes. Some of the other experiments included space exposure profiles of plastics, optics, and tomato seeds. — *William L. Taylor, Seaford, Virginia*

[continued on page 12]


M23
Neptune
Saturn
M21
M20
Trifid Nebula
Uranus
M8
Lagoon Nebula
M22
M28
Kaus Borealis
Sagittarius
Nunki
Ascella
M54
Kaus Media
Alnasl

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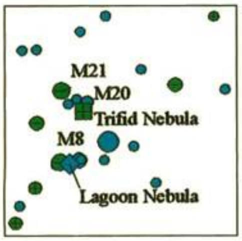
M21
M20
Trifid Nebula
M8
Lagoon Nebula

Plan your observation sessions with spectacular, professional-quality star chart printouts.

What program offers as rich and unrivaled a display of deep-space objects, including Messier and NGC objects, in stunning full-color images, at speeds to dazzle an Einstein?
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So for those who ever wondered at a falling star, or warmed to track the icy scarps of Neptune, or dreamed of sailing solar winds to distant galaxies and nebulae, where else is there to look?
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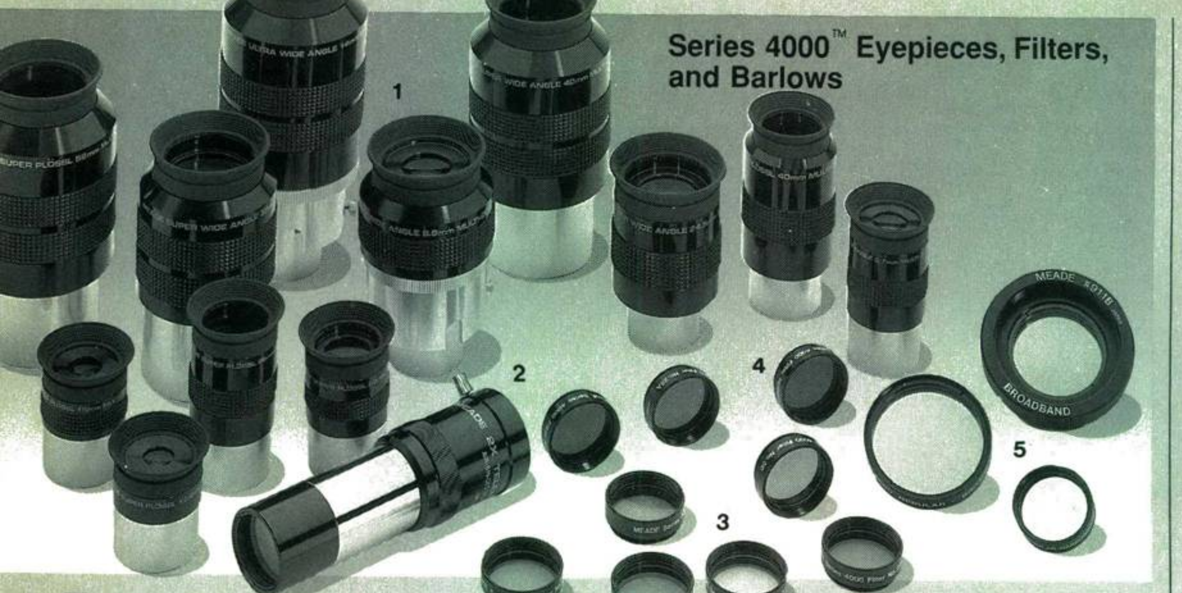

Series 4000™ Eyepieces, Filters, and Barlows

1 The World's finest telescope eyepieces now include rubber grips and soft rubber eyeguards for an even better observing experience! All eyeguards fold down for eyeglass wearers—a feature not available on competing brands. Best of all, **Meade Series 4000's are guaranteed to deliver more field, more contrast, and more image sharpness than any other brand at any price, or your money back.*** For splitting the closest doubles, revealing tenuous, faint nebulosity in deep-space, or studying hairline lunar and planetary detail, Meade multi-coated Series 4000's are the oculars that serious observers insist upon. ***"Clearly the best."***

Super Plössls (5-elements; 1.25"; 52°):
6.4; 9.7; 12.4; 15; 20; 26mm ea **$87.95** (3.29)
32mm(52°); 40mm(44°); each **109.95** (3.79)
56mm (52°, 2") **229.95** (4.18)

Super Wide Angles (6-elements; 1.25"; 67°):
13.8mm: **139.95** (3.29) 18mm: **149.95** (3.29)
24.5mm: **169.95** (3.79) 32mm(2"): **239.95** (4.18)
40mm(2"): **299.95** (4.18)

Ultra Wide Angles (8-elements, 1.25"; 84°):
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*at participating dealers; see catalog for details.

2 **#140: Series 4000 2x Apochromatic Barlow Lens** (1.25")--The original Meade 3-element, air-spaced, multi-coated design. Absolutely unmatched in image resolution and color correction. 28mm dia. lens (26mm clear aperture). **$79.95** (3.29)

3 **Series 4000 Photo-Visual Color Filters** (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast on the Moon and planets . Thread into virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow-Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue.
each **$12.95** (2.29)

Set #1—4 filters: #12 Yellow, #23A Lt.Red, #58 Green, #80A Blue **$49.95** (2.79)

Set #2—4 filters: #11 Yellow-Green, #25A Red, #47 Violet, #82A Lt. Blue **$49.95** (2.79)

Set #3—4 filters: #8 Lt. Yellow, #21 Orange, #38A Dark Blue, #56 Lt. Green **$49.95** (2.79)

Sets #1 & #2—8 filters **$89.95** (3.29)

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4 **Series 4000 Moon Filter** (1.25")—Excellent for 4" to 12" telescopes. Reduces Moon brightness by 87%. **$15.95** (2.49)

5 **Series 4000 Nebular Filters**—The very latest in multi-layer interference coating technology, Meade premium nebular filters are guaranteed to be the finest obtainable at any price. Use a Series 4000 Broadband filter to block most forms of light pollution, with minimal attenuation of desired wavelengths. Use a Narrowband filter in heavily light-polluted areas, or for extremely high contrast observing of faint nebulae.

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#911B--Threads on to the rear cell of Schmidt-Cassegrain telescopes. **99.95** (3.29)

NARROWBAND FILTERS

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#911N--Threads on to the rear cell of Schmidt-Cassegrain telescopes. **119.95** (3.29)

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The finest focusers in the industry. Meade rack and pinion mechanisms have precise, ultra-smooth action along the entire travel distance. Housings are machined for tight fit of the moving sleeve. All focuser models may be used on tubes of from 4" to 20" diameter; all accept 1.25" eyepieces. Mounting hardware included.

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#680--The most popular 2" focuser ever manufactured. Thousands in use. Spring-loaded gearbox; 3" travel. Includes 1.25" and 2" eyepiece-holders. **99.95** (3.78)

#682—Low-profile 2" focuser; body height only 1.75". Spring-loaded gearbox. Travel: 2.5". Includes 1.25" adapter. **99.95** (3.78)

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#637: 6 x 30mm-Fine, 7° wide-field finder; coated, achromatic lens; crosshair eyepiece, 2-ring bracket with alignment screws. Attaches to tube diameters 6" to 12" **$49.95** (3.29)

#545: 8 x 50mm-(*lower photo*) Wide 5° field; coated achromatic objective; crosshair eyepiece. White tube. Ideal for telescopes of any aperture. See bracket below. **69.95** (4.28)

#544: 8 x 50mm--Same as #545, but in Meade blue. **69.95** (4.28)

#957: 9 x 60mm—(*top photo*) Collects 44% more light than 50mm; superior for faint objects; bracket below. **99.95** (4.68)

Bracket for 8 x 50mm: Fits Meade and Celestron SCT's, and other tubes from 7" to 20" diameter. **17.95** (2.79)

Bracket for 9 x 60mm: Fits tubes from 7" to 20" diameter. Removable dovetail included. **22.95** (2.79)

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#927: for .965" focusers.
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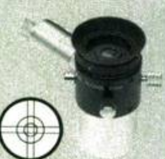
#931 Hybrid: accepts 1.25" eyepieces, fits .965" focusers.

Specify model desired. each **$49.95** (2.79)

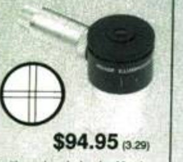
World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Internal batteries included. Multi-coated optics. Bullseye reticle. 1.25" **$129.95** (3.29)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$109.95** (3.29)

MA 12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Includes wireless red LED illuminator with internal batteries and variable brightness control. **$94.95** (3.29)

MA 12mm-Same as above, but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$74.95** (3.29)

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#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter **$99.95** (3.29)

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Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": **$27.95** (2.79) 1.25": **$29.95** (2.79)

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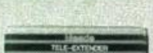
Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-Mount for your camera. **$39.95** (2.79)

Tele-Extenders



For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

Basic Tele-Extender: (*above*) Fixed projection power; use with eyepiece for lunar and planetary photos. **$29.95** (2.79)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece. **$39.95** (2.79)

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#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.29)

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#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25" **$59.95** (3.29)

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HOW TO ORDER

- ■ Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- ■ Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- ■ Meade accessories may be ordered from any Meade Advanced Products dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA
Orders: 800-843-4780; Info: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info: 718-436-6262.

LUMICON, Livermore, CA.
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SHUTAN CAMERA & VIDEO, Chicago, IL.
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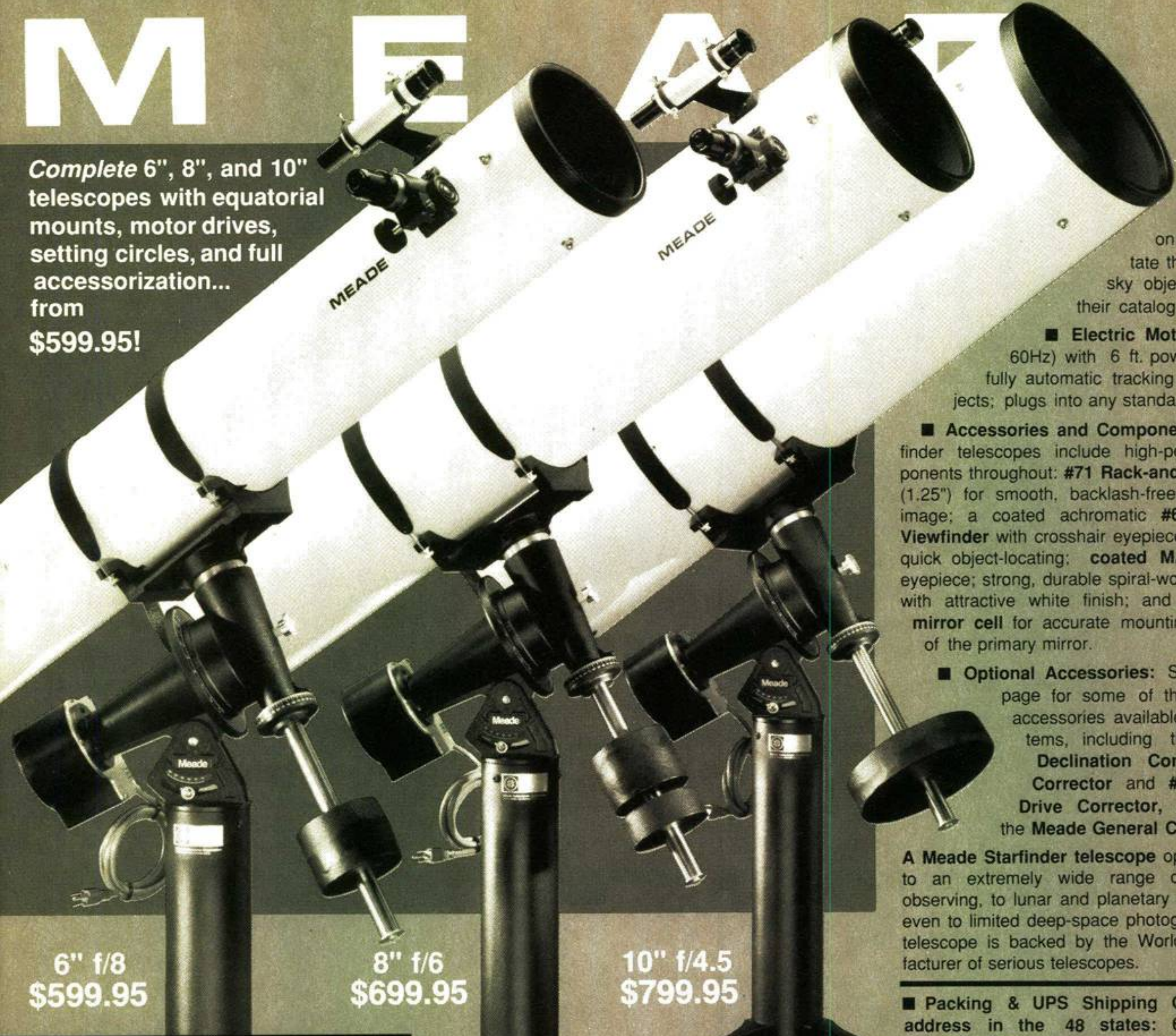

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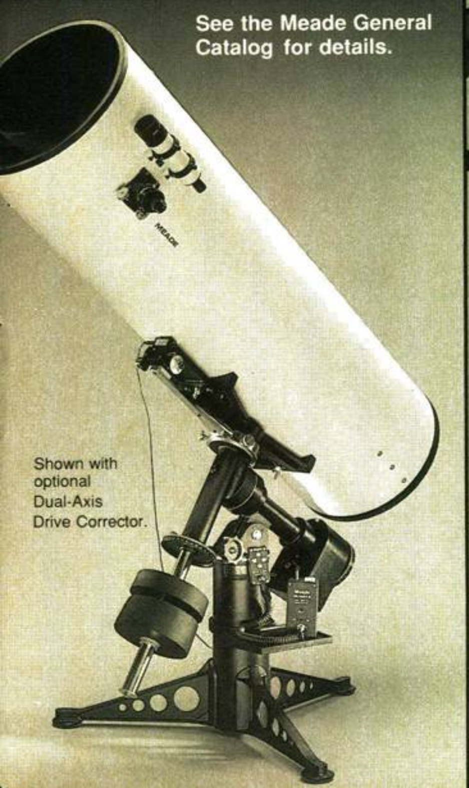
See the Meade General Catalog for details.



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- **Accessories and Components:** Meade Starfinder telescopes include high-performance components throughout: **#71 Rack-and-Pinion Focuser** (1.25") for smooth, backlash-free focusing of the image; a coated achromatic **#637 6 x 30mm Viewfinder** with crosshair eyepiece and 7° field, for quick object-locating; **coated MA 25mm** (1.25") eyepiece; strong, durable spiral-wound **optical tube** with attractive white finish; and **cast aluminum mirror cell** for accurate mounting and alignment of the primary mirror.
- **Optional Accessories:** See the opposite page for some of the many optional accessories available. Additional systems, including the **#55 Manual Declination Control**, **#43 Drive Corrector** and **#47M Dual-Axis Drive Corrector,** are described in the **Meade General Catalog.**

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- **For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:**

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8″ Model 2080A:
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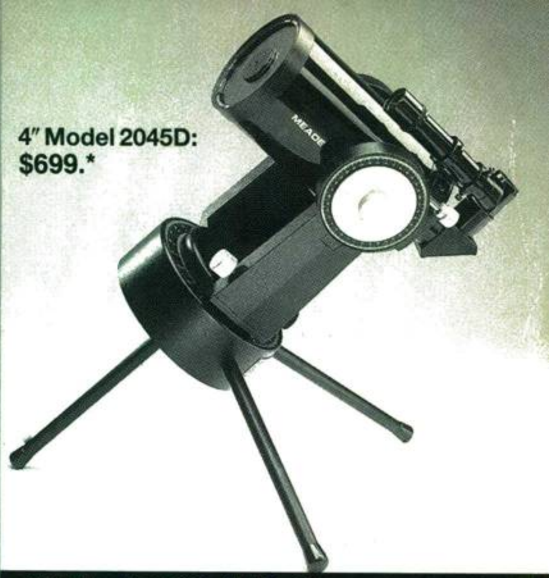

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For the beginning astronomer the lightweight and easy-to-use Meade 2045D packs a powerful potential for serious observing. As a second telescope for the advanced amateur, the 2045D permits wide-ranging observations in locations inaccessible or inconvenient to larger instruments. Each telescope includes optics manufactured to the same high performance standards as larger Meade models. The DC drive system operates from a micro battery pack for convenient field use. Full accessorization is available for virtually any field application.

Specifications: Model 2045D — Complete with 4″ f/10 Schmidt-Cassegrain tube assembly with super multi-coated optics; fork mount with setting circles, manual slow-motion controls, and locks on both axes; 12-volt DC pulse motor, spur gear drive system; AA battery pack (batteries are not included); tabletop tripod system; eyepiece holder/diagonal prism; coated MA 25mm (40X) eyepiece (1.25″); 5 x 24mm viewfinder. .... **$699.**

Packing and shipping in the 48 states .... $40.

Specifications: 8″ Model 2080A — Complete with 8″ f/10 Schmidt-Cassegrain optical tube assembly; fork mount with setting circles, manual slow-motion controls and locks on both axes; 5.75″ worm gear motor drive system (115v./60Hz); eyepiece-holder (1.25″); diagonal prism; coated MA 25mm eyepiece (1.25″); 6 x 30mm viewfinder; equatorial wedge; variable-height all-metal field tripod. .... **$1099.**

Model 2080B — Identical to Model 2080A, but in addition with Super Multi-Coated optics. .... **$1149.**

Packing & shipping on either 8″ model in the 48 states: . $95.

Specifications: 10″ Model 2120A — Complete with 10″ f/10 Schmidt-Cassegrain optical tube assembly; fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75″ worm gear motor drive system (115v/60Hz); eyepiece holder (1.25″); diagonal prism; coated MA 25mm eyepiece (1.25″); 8 x 50mm viewfinder; equatorial wedge; variable-height all-metal field tripod. .... **$1379.**

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■ **Variable-Height All-Metal Field Tripods:** The finest tripods yet developed for SC telescopes, the ultimate in rigidity and low-damping time.

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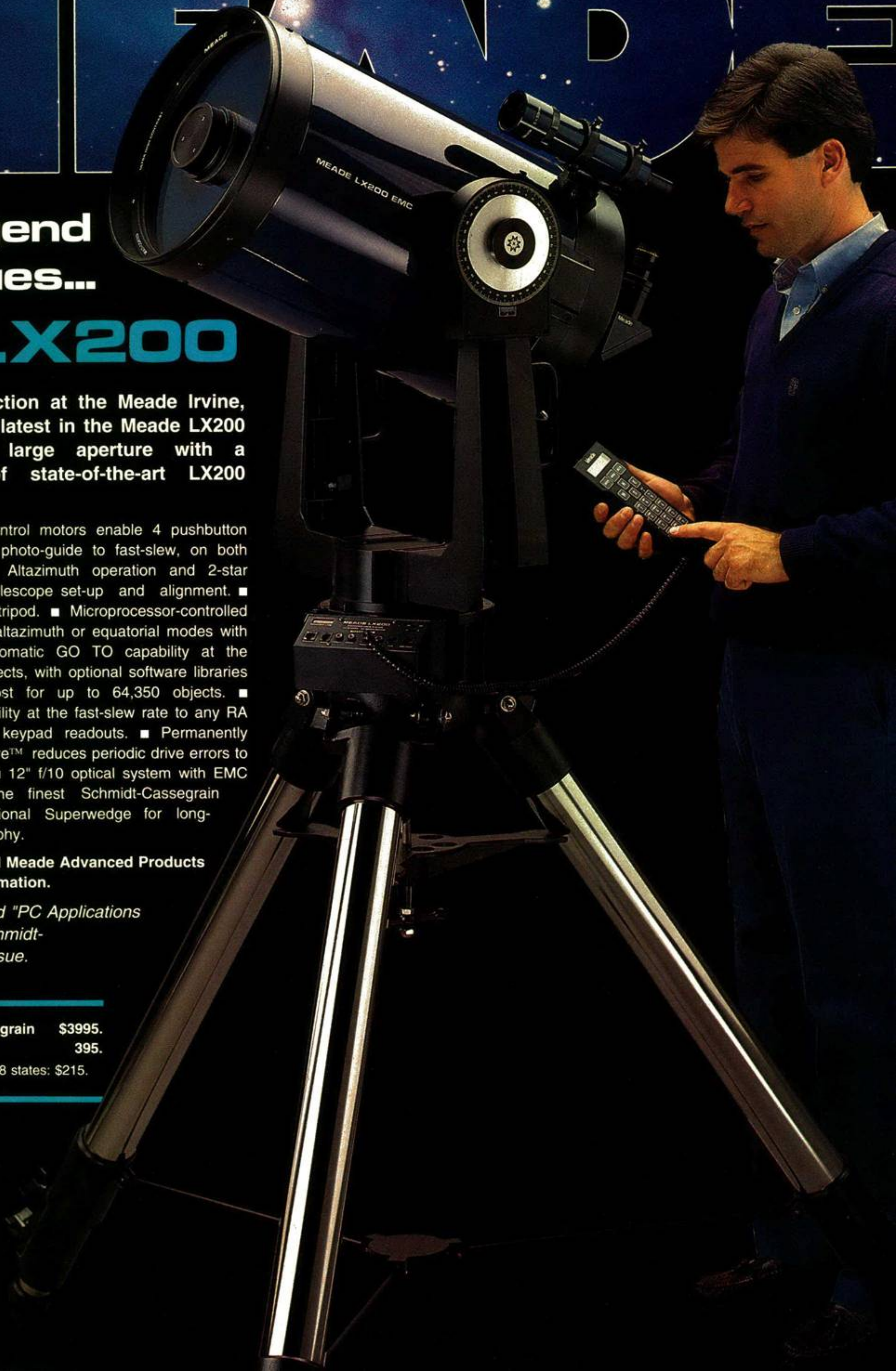

The legend continues...

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Contact your authorized Meade Advanced Products dealer for delivery information.

See also the Meade ad "PC Applications with Meade LX200 Schmidt-Cassegrains" in this issue.

12" LX200 Schmidt-Cassegrain	**$3995.**
Superwedge 12"	**395.**

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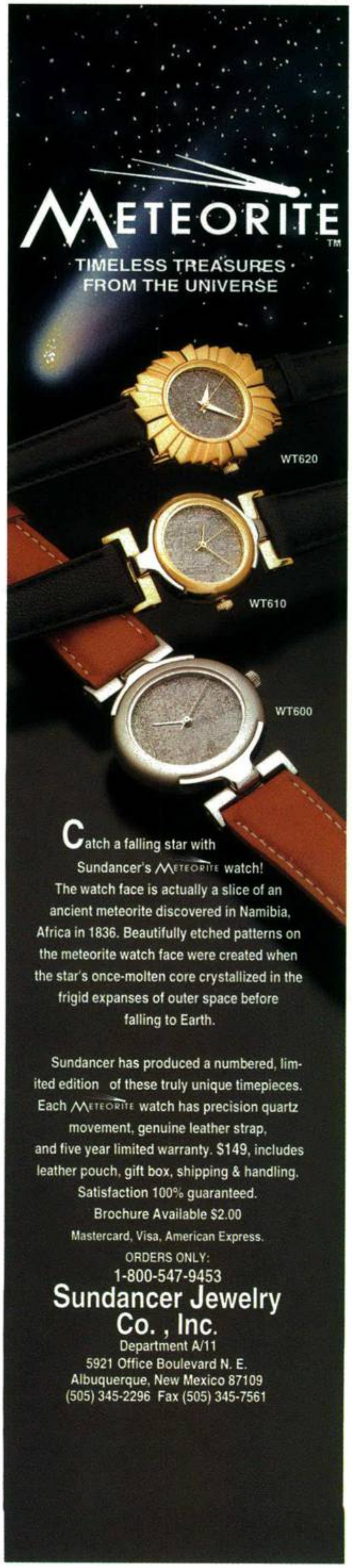

Catch a falling star with Sundancer's METEORITE watch! The watch face is actually a slice of an ancient meteorite discovered in Namibia, Africa in 1836. Beautifully etched patterns on the meteorite watch face were created when the star's once-molten core crystallized in the frigid expanses of outer space before falling to Earth.

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A Real Age Paradox

While reading "The Age Paradox" by Ray Jayawardhana (June 1993) I noticed that on page 39, at the very, very bottom, in the lined box, third line down, 11th word over, you put *million* instead of *billion*. Please mention that I took the time to write telling you about that one word. — *Angela Oxley (age 10), Mrs. Wittner's Class, Christa McAuliffe Grade School, Oceanside, California*

In "The Age Paradox," Jayawardhana states, "but galaxies don't actually move through space. They are being pulled along with space as it expands. This expansion was caused by the Big Bang, the massive explosion that formed the universe." However, on page 34 of Steven Weinberg's recent book *Dreams of a Final Theory*, Weinberg explicitly states that space is *not* expanding but instead the distances between the objects in it are growing.

Indeed, if space were expanding wouldn't the measuring rods we use also expand, giving us a net result of no perceived expansion? — *Louis Lavoie, Plymouth, Minnesota*

— Most astronomers accept the interpretation that the Big Bang created space-time and that redshifts result from the expansion of space-time. Inflationary theories demand that space expands. Weinberg instead interprets the Big Bang as an explosion that threw matter into space.

Newsletter for Small Scope Users

A new newsletter devoted to observing with small telescopes is slated to come off the press this autumn. Called *8 and Under!*, the publication will focus on observations made with 2-inch to 8-inch telescopes. Articles will cover a variety of topics including variable stars, deep-sky and planetary observing, and astrophotography. Interested subscribers or authors wishing to submit manuscripts should contact the publisher at *8 and Under!, 4 Kingfisher Place, Audubon Park, NJ 08106*

A Really Incredible Resemblance

In your "A Peculiar Twist" (June 1993) the illustration is captioned as a computer simulation of the twisting of a galaxy's disk, "resulting in a shape incredibly similar to that of NGC 4753," which is shown on page 37.

Isn't the bottom frame on page 36 a little *too* incredibly similar to the image of NGC 4753? Was the image of the galaxy superimposed on the final frame of the simulation without its being mentioned to the reader? This last frame seems to show something more than the grid in the sequence undergoing a change in shape. — *James Perlman, Paradise Valley, Arizona*

— The frame second from the bottom shows the final simulation shape. It is superimposed on the image of NGC 4753 in the last frame to show how well they match.

Comment on Astro-Physics Review

I would like to clarify a few points raised about our mountings in the review of Astro-Physics telescopes (September 1993). As stated, the 50-pound weight of our model 1200 mount's pier is correct but this is the weight of the fully assembled pier. The heaviest part, the base of the pier, weighs only 19 pounds. As an option we offer an aluminum field tripod that weighs just over 20 pounds and delivers most of the rigidity of the pier.

The statement on the backlash in the mountings needs some clarification. All gear driven mountings have backlash between the worm wheel and worm gear. This generally is of no consequence in astrophotography because the right ascension motor is always driving the gear in one direction and guiding is done by slowing down or speeding up the motor.

In declination, however, the motor and all the gearing in the train must reverse to reverse the motion of the guide star on the reticle. This can cause a delay, or dwell time, of two to five seconds before the guide star seems to move in the opposite direction. However, if the hand controller buttons are activated properly, dwell time can be reduced to less than one second in any of our mountings.

To do this, I recommend guiding by pulsing the button for only a fraction of a second and then noting the new position of the guide star. If it has not moved far enough, then pulse it again. Even when the declination motion needs to be reversed, it rarely takes more than 5 to eight pulses in rapid succession, each lasting less than $^1/_{10}$ second to get the star recentered. — *Roland Christen, president, Astro-Physics, Rockford, Illinois* ☐

ASTRONOMY welcomes suggestions and additional information about articles and astronomy in general. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

STRANGE CASES!

Ripped from the files of astronomical history

by Kevin Krisciunas

Astronomers are strange. We stay awake when others sleep. We shun lights and carry out our activities under a cover of darkness. We isolate ourselves on mountain tops and remote dark sites. We travel around the globe to see a few minutes of an eclipse. Even we wonder what motivates us.

Compounding our reputation for eccentricity are some unusual stories associated with astronomers of the past. An excursion into the field of astronomical sociology turns up some classic cases.

One of the best-known oddball astronomers was the great pre-telescopic observer Tycho Brahe (1546-1601). Tycho's island observatory at Hven, Denmark, cost about 30 percent of the annual revenues of the Danish crown, or about $5 billion in today's money. In return for this investment, Tycho increased the accuracy of stellar positions by a factor of 10, and his observations of Mars led to Kepler's Laws and Newton's Law of Gravity.

But Tycho also had an elk sent as a present to his mentor, the Landgrave of Hesse-Cassel. En route the elk walked up the steps to a manor house, where it drank a great quantity of beer. On the way down the stairs it broke a leg and died.

Many astronomers know that Tycho lost the bridge of his nose in a duel with his third cousin and that he wore a prosthetic nose piece, supposedly made of pure gold. Fewer know that Tycho was exhumed in 1901 by Czech scholars who were investigating, among other things, the composition of his nose piece, which they found to contain gold, silver, and copper.

Then there was the French astronomer Guillaume Le Gentil (1725-1792) and his valiant efforts to observe the transits of Venus across the disk of the Sun. These transits took place in 1761 and 1769. The first transit found him stuck in the middle of the Indian Ocean, unable to land at his destination at Pondicherry, India, because the French colony had been captured by the British. Le Gentil's observations from a rocking boat were useless. Rather than return to France, Le Gentil decided to wait eight years for the next transit, which would occur on June 4, 1769.

After a long side trip to the Philippines, Gentil finally arrived at Pondicherry (now safely back in French hands) in 1768. The weather was clear for the month prior to the transit, but the sky clouded up on transit day, only to clear immediately after the long-awaited event. Le Gentil was shattered. To make matters worse, he contracted dysentery and remained bedridden for nine months.

He finally boarded a French cargo ship in 1770. After a disastrous encounter with a hurricane off the Cape of Good Hope, the ship was forced back to Mauritius in the Indian Ocean. Determined to reach home, Le Gentil booked passage on a Spanish warship. After a storm-tossed voyage, the ship at last reached Spain in August 1771. Le Gentil crossed the Pyrenees on foot and stepped onto French soil again after an absence of 11$\frac{1}{2}$ years — only to learn that he had been declared dead, his estate looted, and its remains divided up among his heirs and creditors.

An even stranger tale concerns the French astronomy popularizer Camille Flammarion (1842-1925). He found himself the love object of a French countess who died at a young age from tuberculosis. They never met, but the young woman made an unusual request to her doctor — that when she died he would cut a large piece of skin from her back where she had had a picture of Flammarion tattooed and take it to the astronomer. Flammarion was to have it tanned and used to bind a copy of his next book. And so it happened. Flammarion's first copy of *Terres du Ciel* was so bound, with an inscription in gold in the front cover: "Pious fulfillment of an anonymous wish. Binding in human skin (woman) 1882."

The most egotistical work in the history of astronomy is *The Sage of Mare Island,* a biography by W. L. Webb about the American astronomer Thomas Jefferson Jackson See (1866-1962). This book, chronicling the "unparalleled" discoveries of See, is in fact an autobiography written in the third person, using a pseudonym.

George Ellery Hale (1868-1938) founded Yerkes Observatory, Mt. Wilson Observatory, and Palomar Observatory. Beginning at age 42, Hale received regular visits from an elf who advised him on numerous matters, including the

[continued on page 15]

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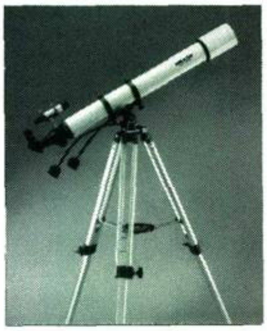

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administration of Mt. Wilson and the planning for Palomar.

One of the most brilliant and most irascible astronomers of all time was Fritz Zwicky (1898-1974). He made many breakthroughs, among them the discovery of the dark matter permeating the Coma cluster of galaxies. In the January 19, 1934 edition of the *Los Angeles Times*, Zwicky was lampooned in a cartoon entitled "Be Scientific with Ol' Doc Dabble," in which the character says, "Cosmic rays are caused by exploding stars which burn with a fire equal to 100 million suns and then shrivel from 1/2-million-mile diameters to little spheres 14 miles thick." In Zwicky's polemical introduction to his 1971 *Catalogue of Selected Compact Galaxies and of Post-Eruptive Galaxies*, Zwicky quotes the cartoon and comments "This, in all modesty, I claim to be one of the most concise triple predictions ever made in science." Why? Because it correctly describes cosmic rays, supernovae, and the formation of neutron stars.

Zwicky was fond of standing up in seminars to remind the speaker that Zwicky had solved the particular question many years before. He also used to refer to other astronomers at Mt. Wilson and Palomar as "spherical bastards." Why spherical? Because, as he put it, they were bastards any way you looked at them. One time Zwicky had the night assistant at the 200-inch fire a bullet out the dome slit to see if that improved the seeing. It did not.

Russian-born Harvard astronomer Sergei Gaposchkin (1898-1984) was once arguing with a night assistant at McDonald Observatory about why they could not find a particular object. The night assistant suggested that one way or another the coordinates were incorrect. Gaposchkin retorted, "I, Sergei Gaposchkin, never make a mistake!" And with that he took one step backward, fell off the observing platform, and broke his arm.

I could go on and on. But to conclude, I often wonder, as my friends suggest, if the term "eccentric astronomer" is redundant. Do astronomers become eccentric as a result of environmental factors such as sleep deprivation? Or do inherently eccentric people become astronomers so they have somewhere to fit in? Astronomical sociologists are hard at work trying to answer these questions. ☐

Kevin Krisciunas is a professional astronomer at the Mauna Kea Observatories in Hawaii.

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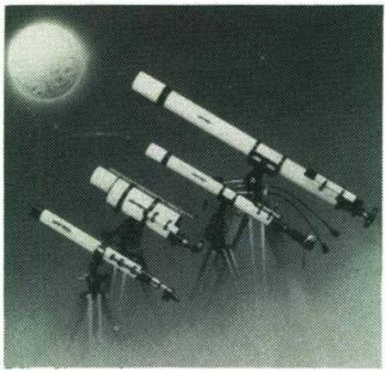

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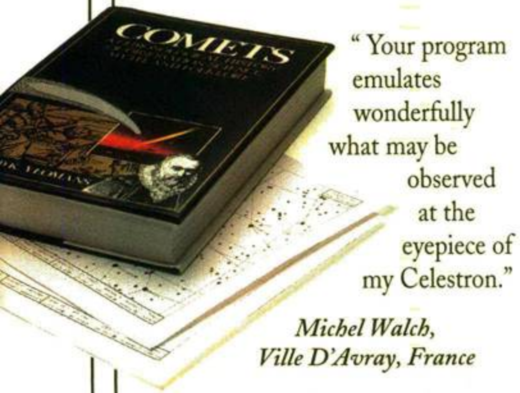

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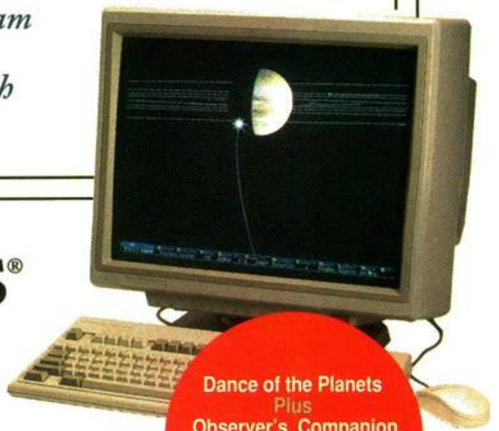
Below - Captured Comet Shoemaker-Levy (1993e) impacting Jupiter, July 1994.



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**Plossl test, "SKY & TELESCOPE," p490-492, May 1988*

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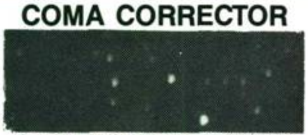

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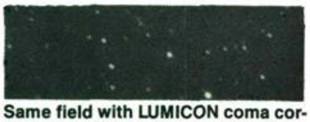

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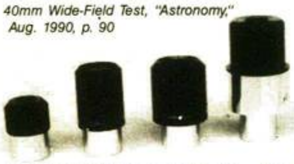
M—33 in Triangulum. 60 minute photo by Len Bright using hypered 2415 film and a **LUMICON Coma Corrector** with a **LUMICON 2" Easy-Guider** in a 12½" f/5 telescope.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90



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2" Giant Barlow - 2x	**$189**
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9mm Nagler, 82° field, 1¼" or 2"	**$219**
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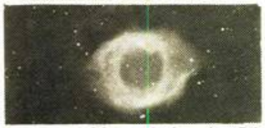
"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

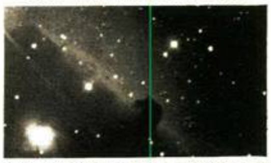
AMAZING OIII FILTER™



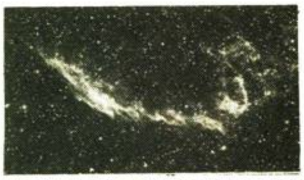
Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!



Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

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BEST WIDE-BAND FILTER!

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Astronomy, Feb. 1991

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2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$119.50**
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DEEP-SKY ASTROPHOTOGRAPHY

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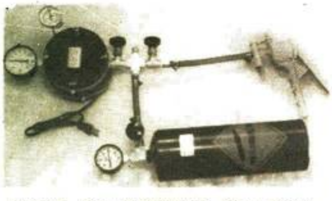

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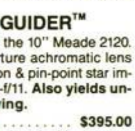

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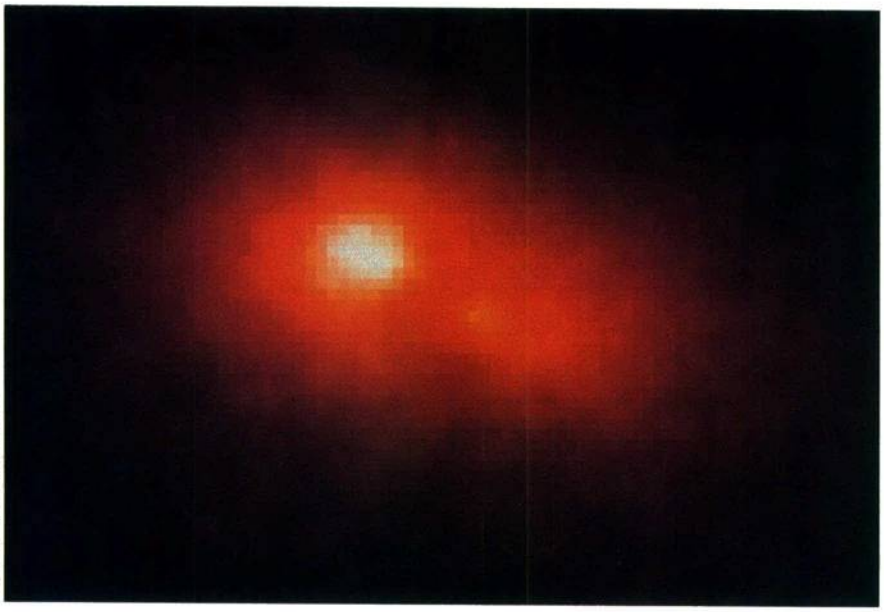
Fuji HG400 fine grain color neg.	12	**$10.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

ANDROMEDA GALAXY HAS A DOUBLE NUCLEUS



T. R. Lauer (NOAO) and NASA

THE HEART OF THE ANDROMEDA GALAXY contains two nuclei separated by five light-years. The brighter one is the nucleus typically observed from Earth, while the dimmer one, seen for the first time in this HST image, marks the true center of the galaxy.

The nearest large galaxy to our own is the giant spiral in Andromeda. Through ground-based telescopes, the Andromeda Galaxy (M31) looks like a typical spiral galaxy with winding arms, clouds of interstellar gas and dust, a central bulge containing billions of stars, and a bright nucleus. But the Hubble Space Telescope recently showed that all is not normal in M31 — its center harbors not one, but two distinct nuclei.

Astronomers Tod Lauer of the National Optical Astronomy Observatories and Sandra Faber of the University of California, Santa Cruz, led the team that discovered the double nucleus on images taken with HST's Wide Field/Planetary Camera. The images show two bright spots at the heart of M31. The dimmer one, surprisingly, appears to mark the exact center of the galaxy.

Where do the two nuclei come from? One possible explanation is that the brighter nucleus is all that remains of a smaller galaxy that fell into M31 a billion or so years ago. But if such a collision occurred, the massive black hole that some astronomers think lies at the center of M31 should have torn apart the remnant long ago.

A second hypothesis is that a thick ring of dust obscures the central area of a huge star cluster in the core of M31. In this scenario we see just the outer parts of the cluster, which create the illusion of a double nucleus. For this to work, however, the dust grains would have to be unusually large, because typical dust grains redden starlight noticeably and there's no sign of this reddening around the center of M31. The final answer to what lies at the center may have to wait until after the astronauts on the Hubble servicing mission correct the optics. Then astronomers can analyze the spectra of both nuclei to see if they belong to a single star cluster and measure the velocities of stars to see if either nucleus harbors a black hole.

GREAT PERSEIDS, NO STORM

The annual Perseid meteor shower peaked on August 12 and provided thousands of skywatchers the opportunity to see bright meteors under a moonless sky.

The event occurred under a cloud of hype due to predictions of a meteor "storm" this year. NASA postponed a space shuttle mission because of the perceived danger of a collision in orbit. Reports from one astronomer predicted the possibility of seeing meteoroids impacting the non-illuminated part of the Moon, causing a visible flash, as the Moon rose before dawn.

The idea of a Perseid storm came about because Comet Swift-Tuttle, progenitor of the Perseids, returned close to the Sun last December. This suggested that Earth might pass through a dense region of cometary debris this year, dramatically increasing the shower's activity.

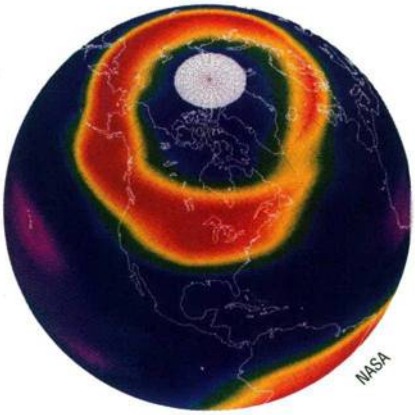
No such storm took place. However, the shower was one of the finest of recent years, producing as many as 110 meteors per hour and a high percentage of bright fireballs. Many of the fireballs produced glowing trains.

The high number of bright meteors delighted beginners and veterans alike. "We saw more fireballs than usual," says Merry Edenton Wooten, who observed the shower from Fort Pickens near Pensacola, Florida. "I didn't notice as many garden-variety meteors but those fireballs I saw were in the magnitude –2 to –5 range — very bright! — and most were orange or red-orange with pretty trains."

Next month's ASTRONOMY will contain full pictorial coverage of the Perseid shower along with extensive observers' reports.

SOLAR CYCLE LINKED TO OZONE HOLE

The fate of Earth's ozone layer is the subject of heated debate. Depletion of the ozone layer has been linked to the



NASA

THE RED COLLAR surrounding Earth's north pole marks a zone where electrons from the Sun penetrate the stratosphere and form nitrogen compounds that may affect global ozone levels. This image is from the Proton/Electron Telescope aboard NASA's SAMPEX satellite.

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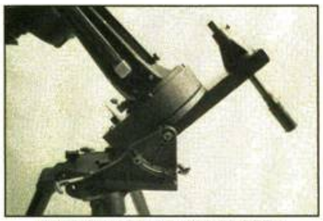
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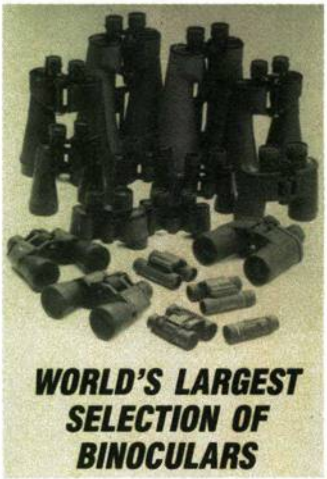

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presence of chlorine atoms injected into the upper atmosphere from aerosol cans and air conditioners. Now, NASA's SAMPEX (Solar, Anomalous, and Magnetospheric Particle Explorer) satellite has found evidence that the 11-year cycle of solar activity may also play a role.

The satellite has mapped areas of the atmosphere bombarded by electrons coming from the Sun. These electrons increase in number when sunspot numbers are at their minimum. When they hit the atmosphere, the solar electrons create nitrogen compounds that can eat away ozone. However, those same nitrogen compounds can also moderate the destructive effect of chlorine atoms, both natural and artificial. Says Linwood Callis, an atmospheric scientist at NASA's Langley Research Center, "We are exploring a new connection that appears to affect global ozone, and with it comes a whole new series of questions for us to examine."

LARGEST FLARE EVER OBSERVED

Thomas Ayres of the University of Colorado and his coworkers have observed the largest flare ever recorded. It wasn't on the Sun but on a star in the Pleiades called Hertzsprung 314 (HZ 314). This 11th-magnitude star is similar in temperature to the Sun but has an age of only 70 million years. Unlike solar flares that cause little change in the overall brightness of the Sun, HZ 314's flare caused the star to increase in brightness by a factor of three in just 20 minutes. The astronomers were using the Hubble Space Telescope's Faint Object Spectrograph to study flaring in young stars and how it changes as stars age. While there is no way of knowing how violent our Sun was early in its life, Ayres says, titanic flares like those observed on HZ 314 would make life on Earth difficult if not impossible.

PIONEER 10: THE ORIGINAL ENERGIZER BUNNY

Like the pink rabbit in the battery commercials, Pioneer 10 just keeps going and going. On June 13 the tiny spacecraft, now at a distance of 5.5 billion miles from Earth, celebrated the 10th anniversary of its crossing the orbit of Pluto. Launched in 1972, the 570-pound spacecraft was supposed to last only 21 months, long enough to take it past Jupiter, its prime target. But the mission has lasted far longer and surprised scientists in the process.

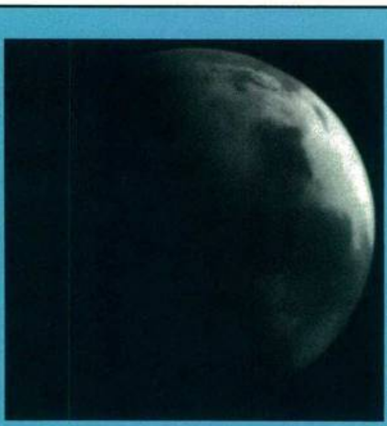
MARS OBSERVER: LOST IN SPACE

On August 20, flight controllers at the Jet Propulsion Laboratory lost all contact with the billion-dollar Mars Observer just as the spacecraft was about to pressurize its fuel tanks in preparation for the planned August 24 insertion into Martian orbit. Valiant attempts that followed failed to regain contact with the probe.

Although the cause of the failure is still being debated, the finger of suspicion seems to point to two transistors in each of the main and backup computer timing clocks. A weather satellite's timing clock contained transistors from the same manufacturing lot and these also failed shortly before launch in June. The transistors failed when a weld between a gold-plated post and an aluminum wire broke. In the case of Mars Observer, the mechanical shock of the valves' opening to pressurize the tanks could have caused a fatal break.

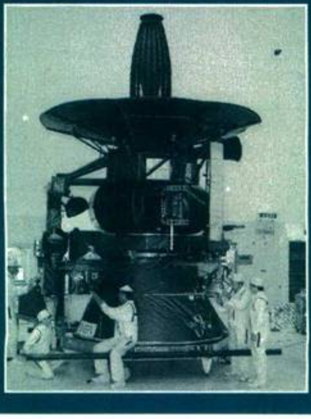
Loss of Mars Observer, though serious, does not affect NASA's plans for its next Mars missions. A small lander called MESUR Pathfinder is tentatively set for launch in 1996 (see August 1993 Astronomy) in advance of a series of 12 MESUR micro-landers NASA hopes to place on Mars later in the decade. NASA can carry out all these flights using existing Mars data. Nevertheless, having more accurate surface maps from Mars Observer would have helped pin down landing sites.

NASA Administrator Daniel Goldin has ordered a study of three options for replacing Mars Observer: build a new Mars Observer from existing spare parts; have private industry build a new craft from scratch; or launch two to four mini-orbiters to Mars in November 1994, each styled after the U.S. Department of Defense's Clementine Moon/asteroid mapper. Set for launch in January, Clementine was completed in only two years at a cost of $100 million. Reports from the teams investigating these options are expected in mid-September.


NASA

MARS'S OBSERVER'S ONLY PHOTO of the Red Planet was taken on July 26 when the ill-fated spacecraft was 5.8 million kilometers from the planet.

GALILEO ENCOUNTERED its second asteroid, Ida, the same week Mars Observer was in the news. On August 28, Galileo (pictured below before launch) flew to within 2,400 kilometers of the 30-km-wide asteroid, exactly as planned. Mission scientists took 21 images of the asteroid but none were available at press time — because of Galileo's antenna woes, the images must be played back over several weeks. Scientists hoped to have several images by the end of September, but the majority will not be played back until spring 1994.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Twenty years later, Pioneer 10 is still sending back signals as it hurtles toward the stars at 50,000 km per hour. Five of the 11 instruments aboard are sending back data through the spacecraft's 7.5-watt transmitter. By the time the signal reaches Earth, the strength has dwindled to 4 billionths of a trillionth of a watt.

Pioneer 10 is now being used to explore the limits of the Sun's wind, to search for a possible tenth planet, and to detect gravity waves from deep space. Says Richard Fimmel, Pioneer 10 project manager at NASA's Ames Research Center, "We take science data from Pioneer 10 daily and will probably continue to do so until at least 1998."

NOT SO NEON NOVA

Early observations of Nova Cygni 1992 led astronomers to believe that the nova occurred when the outer layers of a somewhat rare oxygen-neon-magnesium white dwarf exploded, forming an expanding shell around the star. (See "Neon Nova," July 1993.) The strong lines of neon detected in the shell's spectrum supported the researchers' conclusion. But now some astronomers think they have been fooled.

The explosion formed dense knots of material in the tenuous shell of hot gas. Originally astronomers used thin-gas models to describe how the shell radiates light and then used these models to estimate how much neon was ejected. Now astronomers at the University of Wisconsin led by Karen Bjorkman and Amy Barger have produced more complex computer models, taking into account the dense knots within the shell. They find the quantity of neon in the shell to be much less than originally estimated and consistent with the amount expected from normal carbon-oxygen white dwarfs.

BRIGHT X-RAY PULSAR DISCOVERED

In mid-July astronomers using the Compton Gamma-Ray Observatory discovered a powerful pulsar in the southern constellation Carina. Designated GRO J1008-57, the object quickly became one of the brightest X-ray sources in the sky, *emitting an intense* pulse of X rays every 93.6 seconds. Compared with hundreds of known radio pulsars, astronomers have discovered only about 30 X-ray pulsars. And the new

Amateur News

UNIVERSE '93 DRAWS RECORD CROWD

Amateur astronomers came from as far away as Australia, Japan, and India to attend. All told, 1,800 astronomy enthusiasts filled the exhibit and lecture halls at Universe '93, a weekend astronomy expo staged by the Astronomical Society of the Pacific in cooperation with ASTRONOMY magazine.

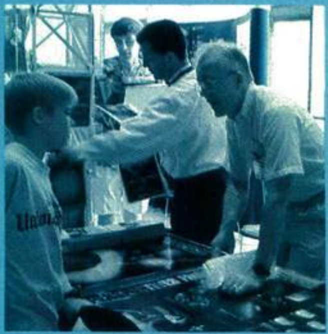
The two-day event, held June 10 and 11 at San Diego State University in California, proved to be the largest indoor amateur astronomy gathering ever held in North America. Visitors were able to tour an impressive exhibit hall filled with booths from 75 exhibitors displaying the latest in astronomy software, telescopes, accessories, and educational services. A line-up of 38 guest speakers filled both days with a full schedule of lectures on everything from the Big Bang to amateur CCD imaging.

Headliners on the speaker program included astronaut Sally Ride, science writer Timothy Ferris, astronomer and space artist William Hartmann, and astrophotographer Jack Newton. In addition, ASTRONOMY magazine staff members Robert Burnham, Alan Dyer, Dave Eicher, Tom Hunt, and Richard Talcott presented talks that gave audiences a look behind the scenes at ASTRONOMY, a preview of celestial events, and a prediction of astronomical discoveries of the next few years.

Many thanks to Ron Angione and his team of volunteers at San Diego State University for organizing a memorable weekend of astronomy.

Next year, the Universe moves to Flagstaff, Arizona, to become one of the key events celebrating the 100th anniversary of Lowell Observatory. The dates for Universe '94 are June 25 and 26 with the site set for the Northern Arizona University campus. For more details, contact the Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94122, (415) 337-1100.

LIKE A SHOPPING MALL FOR ASTRONOMY, the large exhibit hall gave Universe '93 visitors a chance to see the latest in hobby merchandise.



"ASK AN ASTRONOMER," a traveling exhibit provided by NASA, was a popular attraction for kids and adults.

ASTRONOMY: All photos by Alan Dyer

HUNDREDS PACKED LECTURE HALLS for talks from speakers such as science writer Timothy Ferris.

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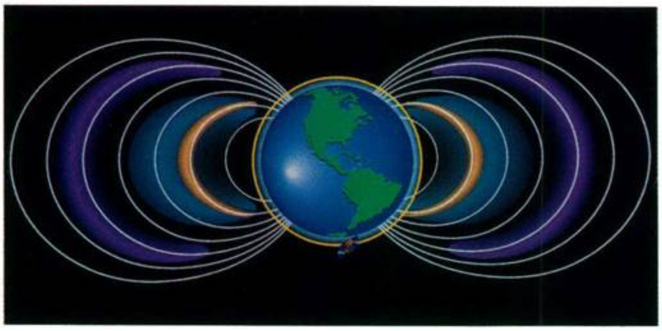
pulsar appears to belong to the even rarer class of transient X-ray pulsars, which has only half-a-dozen members. These pulsars vary enormously in brightness over periods ranging from hours to years.

Astronomers think the X-ray outbursts come from a neutron star located in a binary system. The neutron star's companion is a high-mass star that loses mass via a strong stellar wind. Some of this matter falls on the dense neutron star, fueling the production of high-energy X rays.

GRO's Burst and Transient Source Experiment first detected the X-ray pulsar on July 14. Just five days later, it had become as bright as any X-ray pulsar in the sky. GRO J1008-57 remained that bright for about two weeks before starting to fade. Since then ground-based astronomers have been searching for an optical counterpart to the new pulsar, but without success as of early August.

Space News

SATELLITE FINDS NEW RADIATION BELT


NASA

EARTH'S NEW RADIATION BELT, marked in yellow, contains particles from the depths of space, allowing astronomers to study interstellar matter right in our own backyard.

A U.S.-German satellite launched in 1992 has discovered a new radiation belt around Earth. The unnamed belt, found by the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX), joins two other radiation belts discovered in 1958 by physicist James A. Van Allen. The new belt lies embedded within the inner Van Allen belt at an altitude of several hundred miles. The belt is most intense over a 5,000-mile-long strip of the Atlantic Ocean between South America and Africa where Earth's magnetic field is weakest.

Unlike the other two radiation belts, which are fed by particles from the Sun, the region discovered by SAMPEX stores particles from interstellar space that come from supernova explosions, stellar winds, and even from the Big Bang itself.

The new radiation belt contains high-energy particles of oxygen, neon, and nitrogen that once drifted between the stars. As they neared the solar system, ultraviolet radiation from the Sun electrically charged the particles. The interstellar atoms were then swept to the edge of the solar system by the solar wind where they collided with a shock front formed where the solar wind meets interstellar gas. The collision accelerated some of the particles back toward Earth where they were trapped by our planet's magnetic field.

Says Jay Cummings, a member of the SAMPEX team, "We should start to see the abundance of particles in the belt increasing over the next three to five years as we approach solar minimum." Weakening solar winds during solar minimum should allow more interstellar particles to arrive from the shock wave boundary. — *Joseph Baneth Allen*

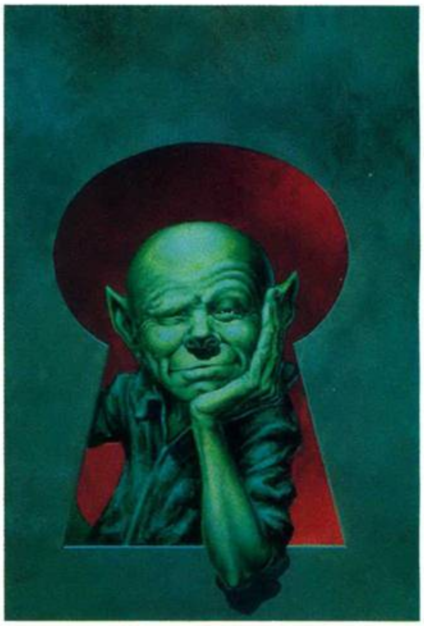
COMPACT DISC BOUND FOR MARS

Sometime in the next century, human explorers on Mars may brush the dust off a decades-old space probe, open the craft, and find a gleaming compact disc inside. If they can reconstruct the technology to play the disc they will hear a portion of the 1938 "War of the Worlds" radio broadcast, a recording made in 1976 at the Jet Propulsion Lab on the night the Viking 1 craft landed on Mars, and time-capsule messages from science fiction writers such as Arthur C. Clarke.

They will also find, in electronic form, several thousand pages of science fiction stories written by authors such as H. G. Wells, Edgar Rice Burroughs, Kurt Vonnegut, Isaac Asimov, and Alexei Tolstoi. All the stories have a common theme — Mars.

The CD, titled *Visions of Mars,* will be placed aboard the Russian spacecraft Mars '94, which is scheduled to land on the surface of the Red Planet in late 1995.

The disc's production is being funded by The Planetary Society and by Warner News Media, which will be selling copies in CD-ROM format for Earth-based consumption. — *Joseph Baneth Allen*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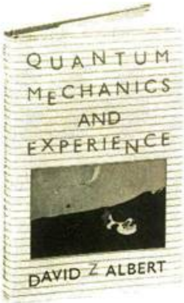
DRAWINGS OF FICTIONAL MARTIANS, such as Frank Kelly Freas' painting from a 1954 cover of *Astounding Science Fiction* magazine, are among the contents of a compact disc being placed aboard the Russian Mars '94 landers.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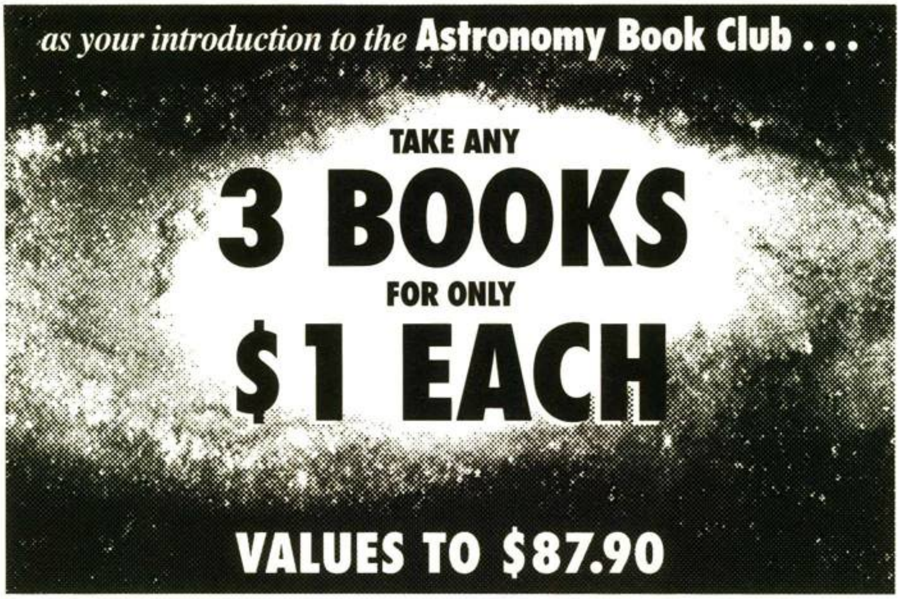

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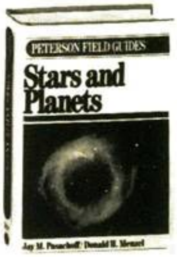
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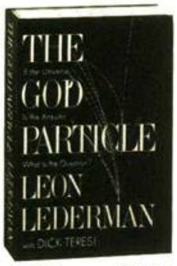
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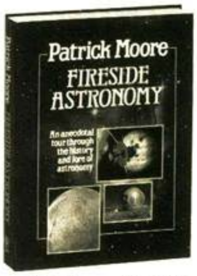
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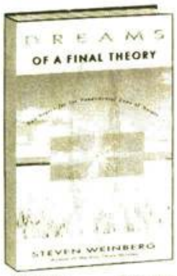
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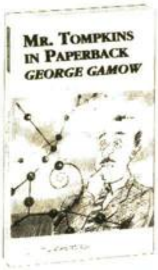
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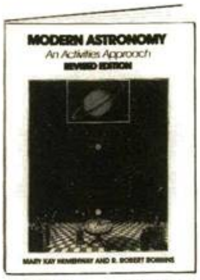
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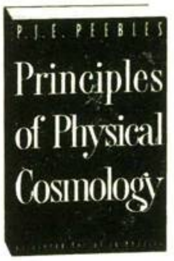
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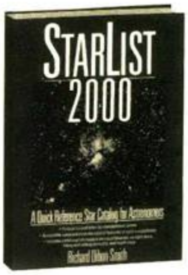
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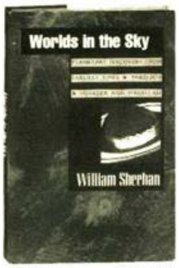
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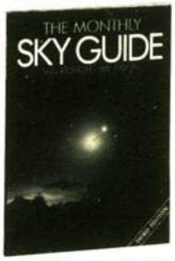
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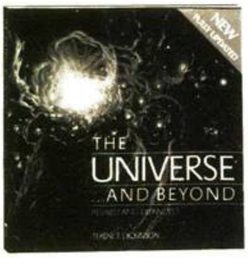
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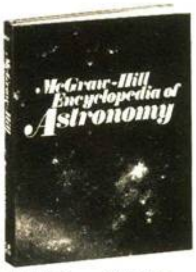
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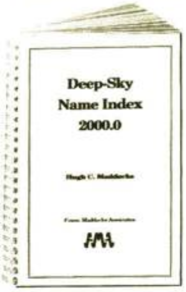
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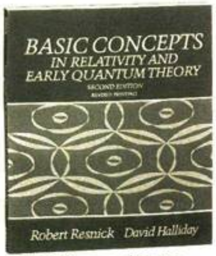
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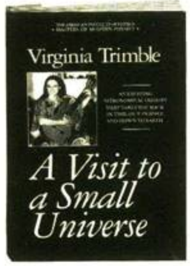
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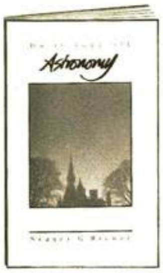

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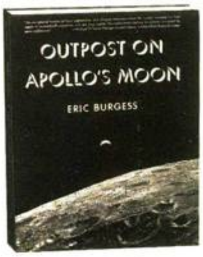
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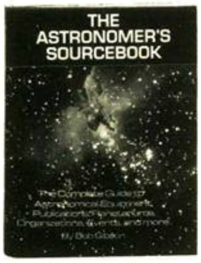
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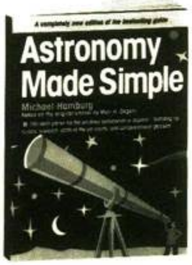
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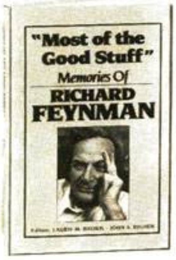
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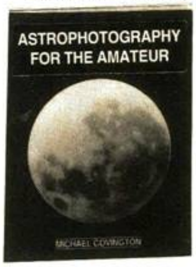
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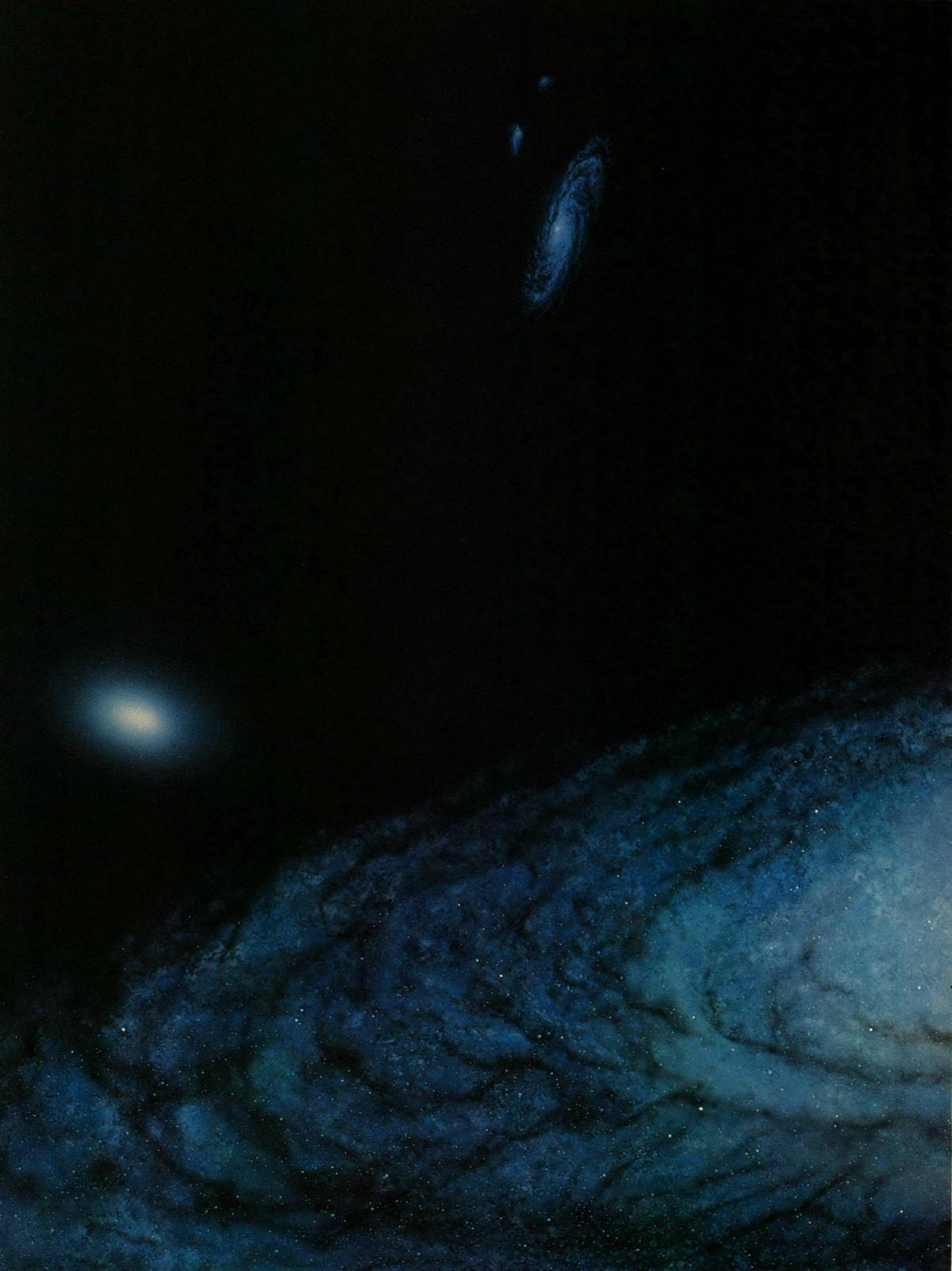
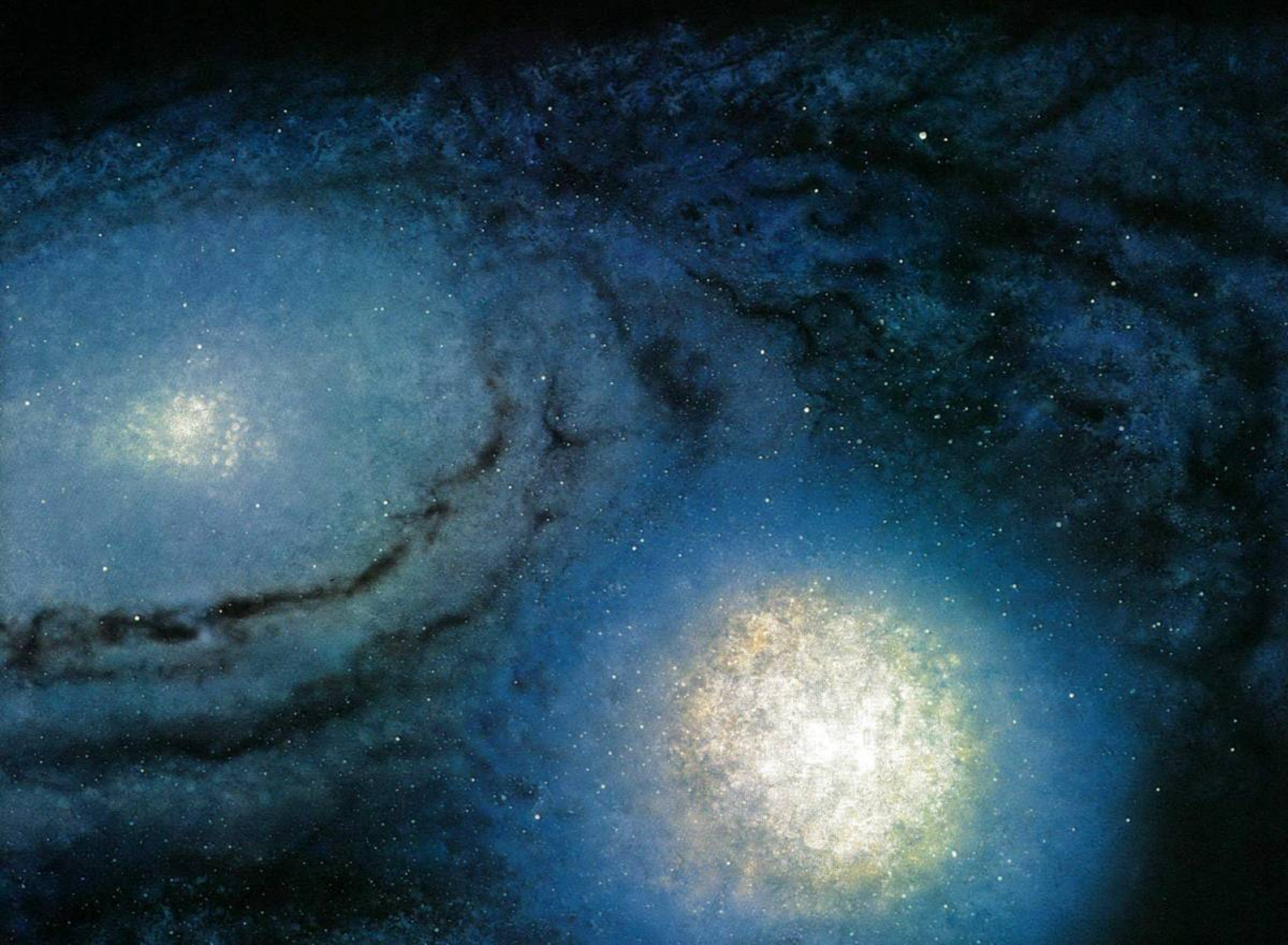


INTRUDER GALAXIES

Five billion years ago, a team of large galaxies may have stormed past the nearby giant Andromeda Galaxy. During the encounter, the giant tossed two of the galaxies out of our Local Group, swallowed their companions, and sent debris flying toward the Milky Way Galaxy.

by Ken Croswell



Our neighborhood of galaxies seems a calm and peaceful place. But recently astronomers have found evidence that about five billion years ago, intruders smashed into the nearby Andromeda Galaxy. Like hit-and-run drivers, these errant galaxies sped away from the scene of their crime and found refuge in an ideal hiding place. The passage of time has largely erased the effects of the collision on the Andromeda Galaxy. In fact, astronomers might not have uncovered the encounter at all if it weren't for the accidental discovery of the intruder galaxies in 1968.

Italian astronomer Paolo Maffei was studying young stars in Cassiopeia. This constellation lies in the plane of our Galaxy and therefore abounds with the dust and gas that create young stars. Amid the young stars and interstellar dust in his photographs, Maffei noticed two mysterious fuzzy blobs. Both looked brighter in the infrared than the red, and neither appeared in photographs taken in blue light. Maffei noted their peculiarity but didn't know what they were.

In 1970, California astronomers led by Berkeley's Hy Spinrad made optical, infrared, and radio observations of the two objects — now named Maffei 1 and Maffei 2 — and concluded that both were large, nearby galaxies. The brighter, Maffei 1, appeared elliptical; Maffei 2 had pinwheel-shaped arms typical of spiral galaxies.

Because they lie in Cassiopeia, behind the Milky Way's thick dust, Maffei 1 and 2 look dim. The dust also produces the odd colors of the galaxies: Dust absorbs blue light more than red and red more than infrared. As a consequence, Maffei 1 and 2 look brighter in the infrared than the red and are barely visible in the blue. If it weren't dimmed by dust, Maffei 1 would almost be visible to your unaided eye and may be the nearest large elliptical galaxy.

Kim Zussman

GALAXY IN EXILE: The large spiral called IC 342 is one of the galaxies astronomers believe the Andromeda Galaxy threw out of our Local Group of galaxies.

Too Fast To Be Close

Since Paolo Maffei's discovery, astronomers have measured the velocity of Maffei 1 and struggled to determine its distance, a task made difficult by the dimming effect of the intervening dust. Maffei 2 has nearly the same velocity but because this galaxy is faint, researchers have studied it less and have yet to determine its distance. In the last five years, they have redetermined the distance of another large galaxy, IC 342, which lies in the neighboring constellation of Camelopardalis. They have discovered that IC 342 may lie as close to us as Maffei 1 does.

The distances of the galaxies should correlate with their speeds away from us. The fact that the universe is expanding causes all except the nearest galaxies to move away from us. Due to the expansion, nearby galaxies move slowly, more distant galaxies more quickly. "But Maffei 1 and IC 342 appear to be too close to be moving so fast," says Gene Byrd, an astronomer at the University of Alabama in Tuscaloosa who has run computer simulations of the motions of the nearby galaxies. "If you extrapolate their motion backward, you find that they and the Andromeda Galaxy must have been rather close to one another about five billion years ago."

If Byrd and his colleagues are right — and they admit their conclusion is only a conjecture — spectacular collisions and encounters have occurred in our galactic backyard. According to Byrd, Maffei 1 and IC 342 were once members of the Local Group. But the galaxies approached the mighty Andromeda Galaxy and its gravity tossed the intruders out of the Local Group. The encounter also shot material toward the Milky Way, giving our Galaxy three of the ten galaxies that now orbit it.

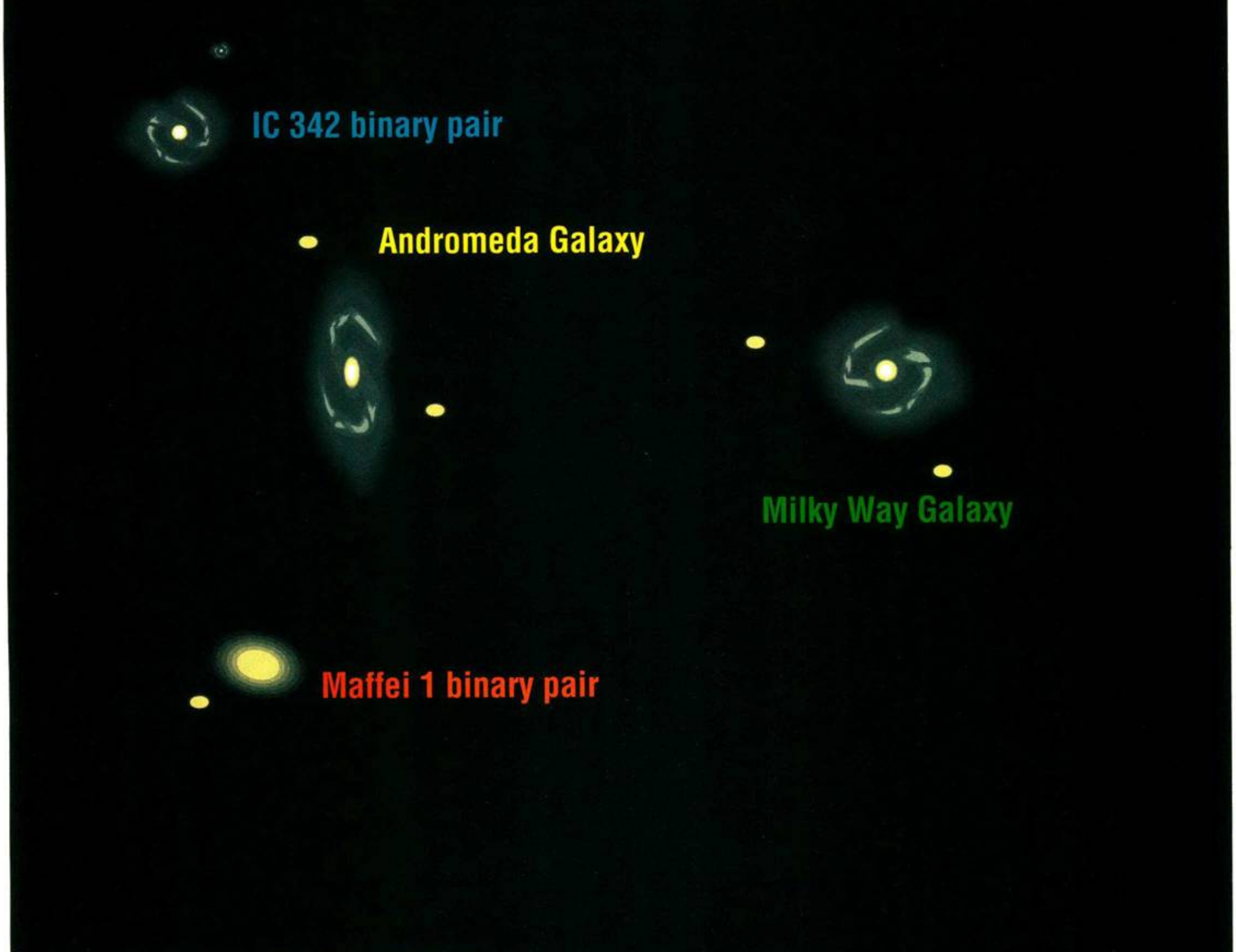
Galactic Geography

To trace the possible flights of Maffei 1 and IC 342, let's step back and examine our galactic neighborhood. The Local Group consists of about thirty galaxies, two of them giants: the Andromeda Galaxy, the largest, and the Milky Way, the second largest. The two giants lie 2.4 million light-years apart, and together they rule the Local Group, for they harbor nearly all its mass.

Each of these celestial superpowers governs an empire of satellite galaxies, which orbit them the way moons circle a giant planet. In fact, most of the Local Group galaxies revolve around either the Milky Way or the Andromeda Galaxy. Our Galaxy has ten satellites, the largest being the Large and Small Magellanic Clouds; others include the Draco, Sculptor, Leo I, and Leo II dwarf galaxies, which take their names from the constellations in which they appear.

The Andromeda Galaxy's empire is equally impressive, boasting seven or eight satellites, including NGC 205 and M32, which are familiar to backyard astronomers. The beautiful spiral galaxy M33, the third largest Local Group member, may also be a satellite of Andromeda. It lies 2.6 million light-years from us, just a bit farther than Andromeda.

OUR NEIGHBORHOOD 5 BILLION YEARS AGO



THE ANDROMEDA GALAXY MAY HAVE CAPTURED two pairs of galaxies about five billion years ago. One pair contained a large spiral galaxy called IC 342 and the other pair an elliptical galaxy named Maffei 1.

ASTRONOMY: Illustrations by Phil Kirchmeier, after Mauri Valtonern, et al.

Pardon My Intrusion

Looking beyond our immediate neighborhood, we find the Local Group sits between two other groups of galaxies — the Sculptor group, which lies due south of the plane of the Milky Way, and the M81 group, which lies north of the plane. Galaxies in the Sculptor group lie 4 million to 10 million light-years from us. The largest is the beautiful edge-on spiral NGC 253. On the other side of the Local Group, the M81 group takes its name from a giant spiral galaxy the size of our own that lies 11 million light-years away in Ursa Major. Maffei 1 and IC 342 are in the general direction of the M81 group, but do not belong to it.

The Sculptor and M81 groups are moving away from us, just as they should be, because space is expanding between them and us and pushes them away from us. The speeds of the Sculptor and M81 galaxies are consistent with their distances. So astronomers reason that neither group has excess motion and neither trespassed into the Local Group in the recent past.

But the same may not be true for Maffei 1 and IC 342. These galaxies have speeds of 145 and 172 kilometers per second. If the galaxies are more distant than M81, then the velocities would be caused entirely by the expansion of the universe.

Although astronomers once believed that the galaxies were that far away, recent measurements suggest the galaxies may be much closer. Thus the expansion of space between us and the galaxies explains only part of their velocities. The rest must come from the motion of the galaxies through space away from us. Using this excess velocity to trace back the paths of the galaxies, Byrd and his colleagues find that Maffei 1 and IC 342 must have traveled through the Local Group.

Dust and Distance

Critical to their argument is the reality of the smaller distances. In the past ten years, much of the burden of establishing those distances has fallen on Marshall McCall of York University, outside of Toronto, Ontario.

"Most distances in the universe are very uncertain," he says. "It doesn't matter how emphatically you claim the distance. It may change by a factor of two tomorrow." He notes that measuring the distances to Maffei 1 and IC 342 is especially difficult.

For most galaxies, determining distance requires knowing only the galaxy's apparent brightness and intrinsic brightness. But because Maffei 1 and IC 342 lie behind the Milky Way's dust, we must also know how much light the dust absorbs. This reduction of light, which astronomers call extinction, decreases the galaxy's apparent brightness. If we neglect or underestimate the extinction by dust, the galaxy will seem fainter and farther than it really is.

In 1970 Spinrad's team estimated that dust absorbs a whopping 99.2 percent of the visible light from Maffei 1 and suggested the galaxy might belong to the Local Group. But later measurements indicated a smaller extinction factor of 94 percent and therefore a greater distance for the galaxy.

Gerard Luppino and John Tonry

THE GIANT ELLIPTICAL Maffei 1 would be one of the brightest galaxies in the sky if not for the intervening dust in our Galaxy that obscures its light.

In 1982 McCall and Ron Buta, now at the University of Alabama, re-examined Maffei 1 in detail. They changed Maffei 1's extinction factor back to 99.1 percent, in close agreement with Spinrad's original result.

But this alone did not give Maffei 1's distance, because they also needed the galaxy's intrinsic brightness. Fortunately, McCall and Buta could use a technique for measuring Maffei 1's intrinsic brightness that Spinrad's team could not. In 1976, two astronomers at the University of California's Lick Observatory, Sandra Faber and Robert Jackson, reported that the greater an elliptical galaxy's intrinsic brightness, the faster the stars in the galaxy move. By applying the Faber-Jackson relation to the motion of stars in Maffei 1, McCall and Buta estimated the galaxy's intrinsic brightness. Their brightness measurement, in conjunction with the extinction and apparent brightness, revealed that Maffei 1 lies only about seven million light-years away, closer than M81.

McCall then studied IC 342, which many astronomers had thought was about 15 million light-years away and some had placed as far as 26 million light-years distant. But when McCall measured this galaxy's extinction, he reached a dramatically different conclusion. "The extinction turned out to be twice as high as people had previously suspected," says McCall, who published a paper in 1989 that reported the extinction to be 89 percent. "On the basis of these measurements, we were led to a distance of only six million light-years. IC 342 would be the third brightest galaxy in the northern sky, after the Andromeda Galaxy and M33, if it weren't behind so much dust." It turns out that IC 342 is a giant spiral galaxy, with an intrinsic brightness nearly as great as the Milky Way's.

The new distances mean that both Maffei 1 and IC 342 are closer to us than they should be, on the basis of their velocities away from the Local Group. Furthermore, because the galaxies lie in the general direction of Andromeda, they are 2 million light-years closer to the Andromeda Galaxy than they are to us. Moreover, the Andromeda Galaxy is moving toward us, so Maffei 1 and IC 342 are moving even faster away from the Andromeda Galaxy than they are from us. McCall ran computer models of the motions of the galaxies that suggested Maffei 1 and IC 342 had encountered the Andromeda Galaxy just a few billion years ago.

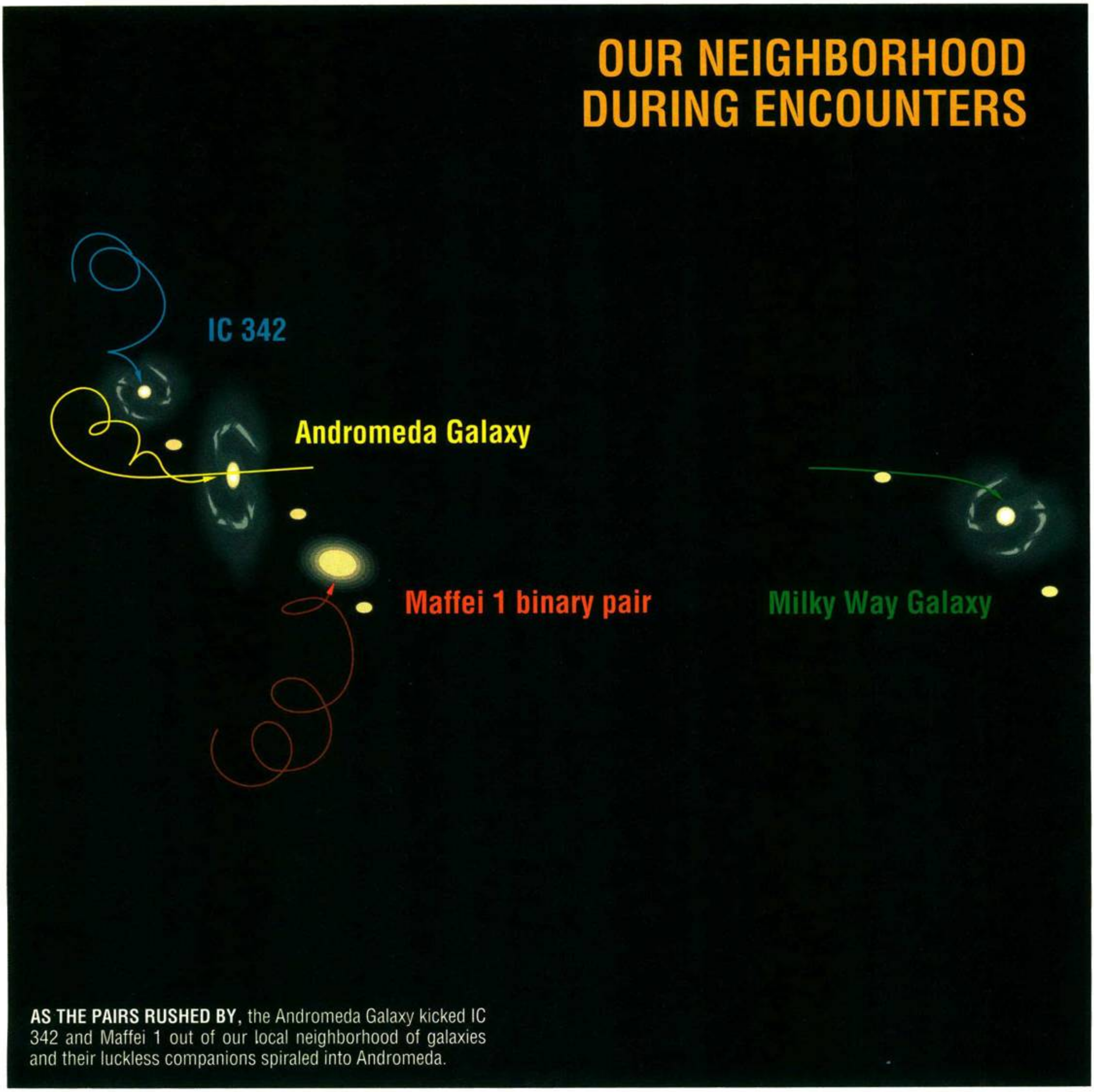
Galactic Encounters

Using McCall's new distances for Maffei 1 and IC 342, together with the previously known velocities, Byrd and Mauri Valtonen of the University of Turku's Tuorla Observatory in Piikkiö, Finland, then performed more sophisticated computer simulations that followed the galaxies back in time.

"We can't be sure exactly what happened," says Byrd, "because in any violent interaction, from what you see afterward, it's hard to construct exactly what was there before. If you see a house exploding, you see all the pieces flying away but it's hard to tell exactly what the house was originally like."

Nevertheless, the simulations that Byrd and Valtonen ran share certain similarities. "We think our Galaxy and a number of other neighboring galaxies moved away from one another due to the expansion of space," says Byrd. "We think that possibly there were

OUR NEIGHBORHOOD DURING ENCOUNTERS



AS THE PAIRS RUSHED BY, the Andromeda Galaxy kicked IC 342 and Maffei 1 out of our local neighborhood of galaxies and their luckless companions spiraled into Andromeda.

two pairs of galaxies, in addition to Andromeda and the Milky Way, that were flying away. The Andromeda Galaxy is quite massive and the smaller pairs of galaxies got pulled toward it. At that point, a very complex interaction occurred."

As the first pair of galaxies approached it, Andromeda captured one galaxy, which soon spiraled into Andromeda, and ejected the other, which is now IC 342. Then the other pair approached Andromeda, and the same thing happened: one galaxy merged with Andromeda, while the other — now Maffei 1 — got ejected from the Local Group at high speed.

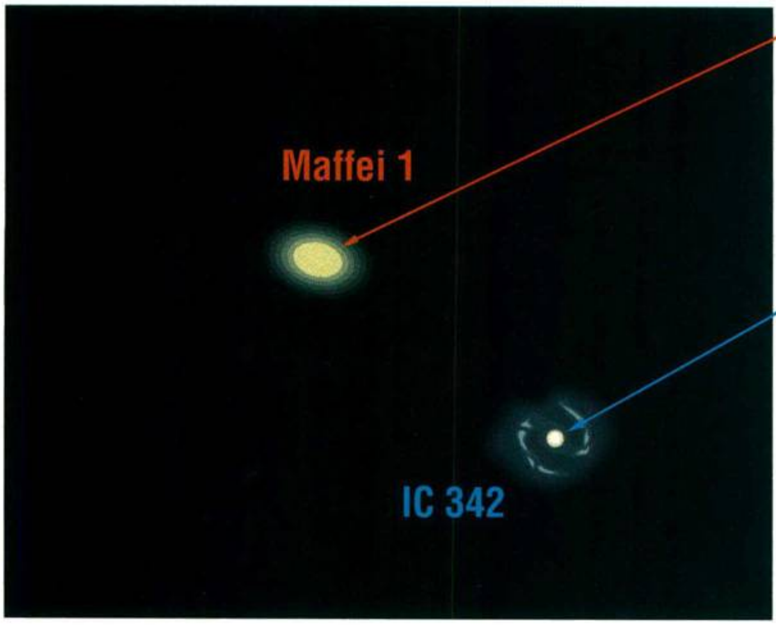
"The pieces of debris — Maffei 1 and IC 342 — are still flying away from us," says Byrd. "It's like an explosion: You see the particles flying away, you measure their speeds, and you can infer when the interaction happened." Byrd's best estimate of when is about five billion years ago.

In contrast with Andromeda "our Galaxy was more of a bystander," says Byrd. "But small pieces of debris flew out of the interaction. We've been looking at the possibility that the Magellanic Clouds were once satellites of the Andromeda Galaxy. So our Galaxy may have gotten splattered with these objects." Key evidence for this assertion is the large sideways velocity of the Magellanic Clouds. Every galaxy orbiting ours has some sideways motion, but that of the Magellanic Clouds is quite large. Byrd believes this indicates that the Magellanic Clouds came from beyond our Galaxy.

Byrd also thinks that another Milky Way satellite, a small galaxy named Leo I, may have been sent our way by the interaction. "Leo I sticks out like a sore thumb," says Byrd. "It has a very abnormal speed compared with the speed of all the other satellites of our Galaxy." Because of their orbital motion around the Milky Way, all the satellites have some velocity either toward or away from us. But Leo I is speeding away from us at 177 km per second, much faster than any other satellite is moving toward or away from us. Furthermore, Leo I lies on the other side of the Galaxy from Andromeda. These two facts suggest that Andromeda may have flung this galaxy toward us. Leo I is already the most distant outpost in the Milky Way's empire, lying 750,000 light-years away. And in the future, its high speed will carry the tiny galaxy even farther from us.

Doomsday Has Been Cancelled

Many astronomers believe that the mighty Andromeda Galaxy itself will someday collide with the Milky Way because it is moving toward us at 120 km per second. But new results indicate no collision will occur. At the suggestion of Kimmo Innanen of York University, the astronomers ran the computer simulations forward to follow the future course of Andromeda and the Milky Way.



"This is a modification of our ideas of what the future of our Galaxy might be," explains Byrd. "Since the Andromeda Galaxy and these other two galaxies, Maffei 1 and IC 342, are flying away from one another, we deduce that the Andromeda Galaxy has a significant sideways velocity. That makes the encounter between our Galaxy and the Andromeda Galaxy a wide one and not head-on. Otherwise, our Galaxy would be in for a great deal of trouble."

Even though our Galaxy and the Andromeda Galaxy won't collide, it doesn't mean that Andromeda isn't disturbed. Because Andromeda has survived past encounters with intruding galaxies, it should still show signs of those collisions today. "The interesting thing," says Byrd's colleague Mauri Valtonen, "is that there seems to be a deficiency of globular clusters near the center of the Andromeda Galaxy. This is the strongest evidence that something has happened to destroy the globular clusters. A merger is a natural explanation." Although a merger can create globulars, strong gravitational forces tear apart the globular clusters near the center of a merging galaxy, whereas more distant globulars survive.

A few months ago, astronomers led by Tod Lauer of Kitt Peak National Observatory in Tucson, Arizona, and Sandra Faber found additional evidence for Andromeda's violent past. Lauer's team used the Hubble Space Telescope and discovered that Andromeda has two nuclei at its center. One of the two components may be the remnant of a galaxy that Andromeda swallowed. (See AstroNews, page 18.)

Any encounters among nearby galaxies not only reveal a drama in our own neighborhood but may also shed light on galaxies throughout the universe. "One of the big issues in astronomy," says McCall, "is how many galaxies — some people claim all large elliptical galaxies — were produced by mergers. So it's particularly interesting that maybe right in our backyard we have an example of a merger. It's important to confirm or deny that statement because it has far-reaching implications for galaxy formation."

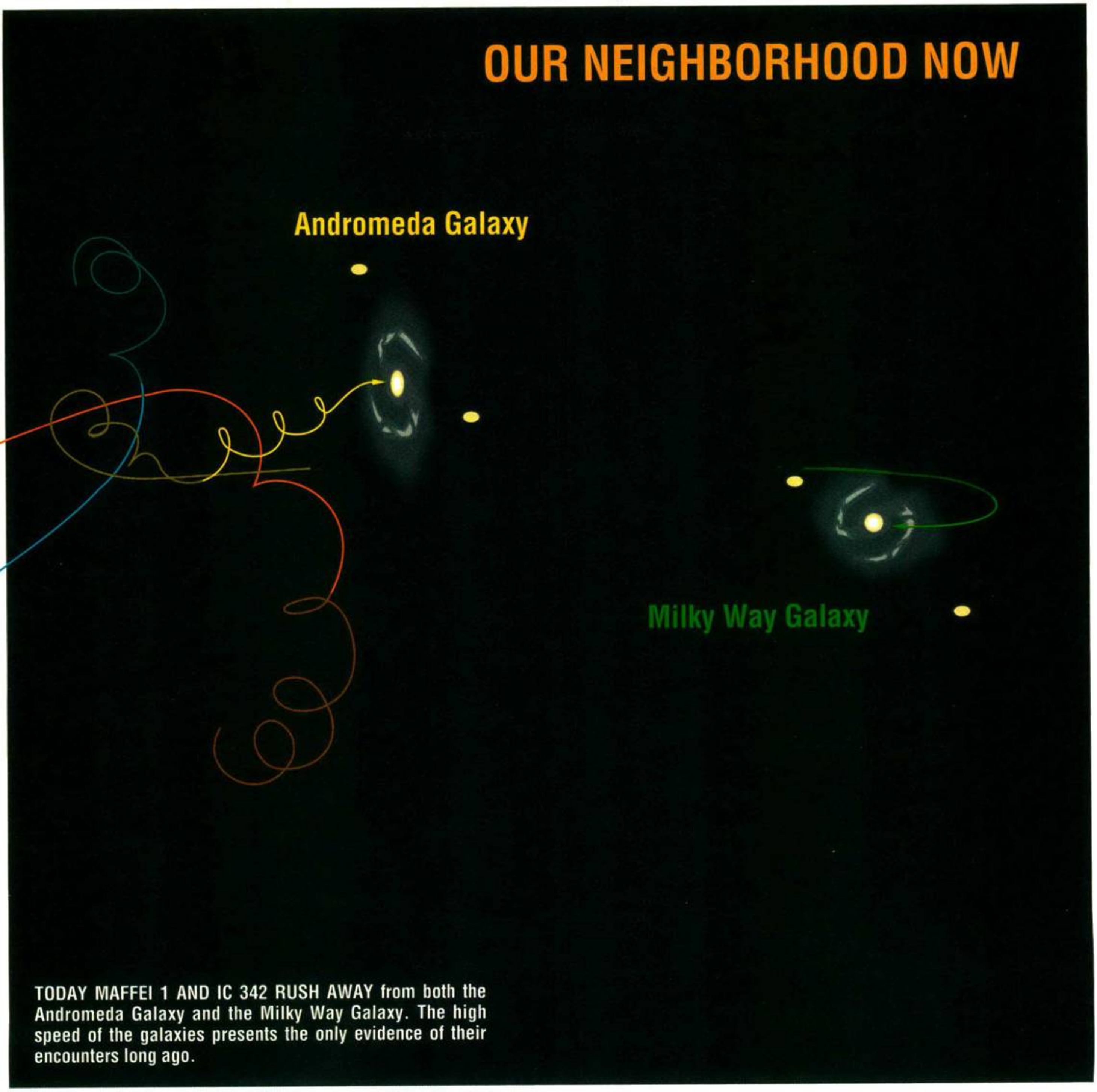
Parting Words

Meanwhile, astronomers struggle to piece together the data they presently have. And Valtonen is confident about his scenario. "As long as the distance estimates don't change," he says, "the encounters of IC 342 and Maffei 1 with Andromeda are a necessary sequence of the Local Group's evolution."

Byrd agrees. "This is a simple extrapolation — it's not anything arcane. You take the galaxies at their current distances and you run their motions backward to see what happened. The only question is, are these galaxies really this close to us?"

Recent work on the distances of the galaxies provides both good news and bad. On the positive side, in 1992 Barry Madore of the California Institute of Technology and Wendy Freedman of the Carnegie Observatories reported new observations of IC 342. Madore and Freedman found that so much dust lies between us and IC 342 that the galaxy's blue stars look yellow-white, which means that the galaxy's extinction is high — in perfect agreement with McCall's 1989 result that suggested IC 342 is nearby.

But in 1993, Gerard Luppino of the University of Hawaii and John Tonry of the Massachusetts Institute of Technology reported that Maffei 1 is distant. They measured the fluctuations in the brightness across the surface of Maffei 1, a characteristic astronomers call smoothness. The stars in a nearby elliptical galaxy produce lots of brightness fluctuations, while the stars in a more distant galaxy blend together, making it appear smoother. Similarly, the solid colors in the picture on this page break up into tiny dots when viewed close-up with a magnifying glass but look smooth from the



TODAY MAFFEI 1 AND IC 342 RUSH AWAY from both the Andromeda Galaxy and the Milky Way Galaxy. The high speed of the galaxies presents the only evidence of their encounters long ago.

normal reading distance. Luppino and Tonry estimate that Maffei 1 is 14 million light-years away, farther than M81 and twice the distance that Byrd and his colleagues have been assuming.

"Well, that would change things," admits Byrd. "But there are two of them — Maffei 1 and IC 342 — so the distances of both galaxies would have to be revised. In some ways, if I had my druthers, I'd prefer only one nearby galaxy because it's a simpler case if there's only one of them flying away."

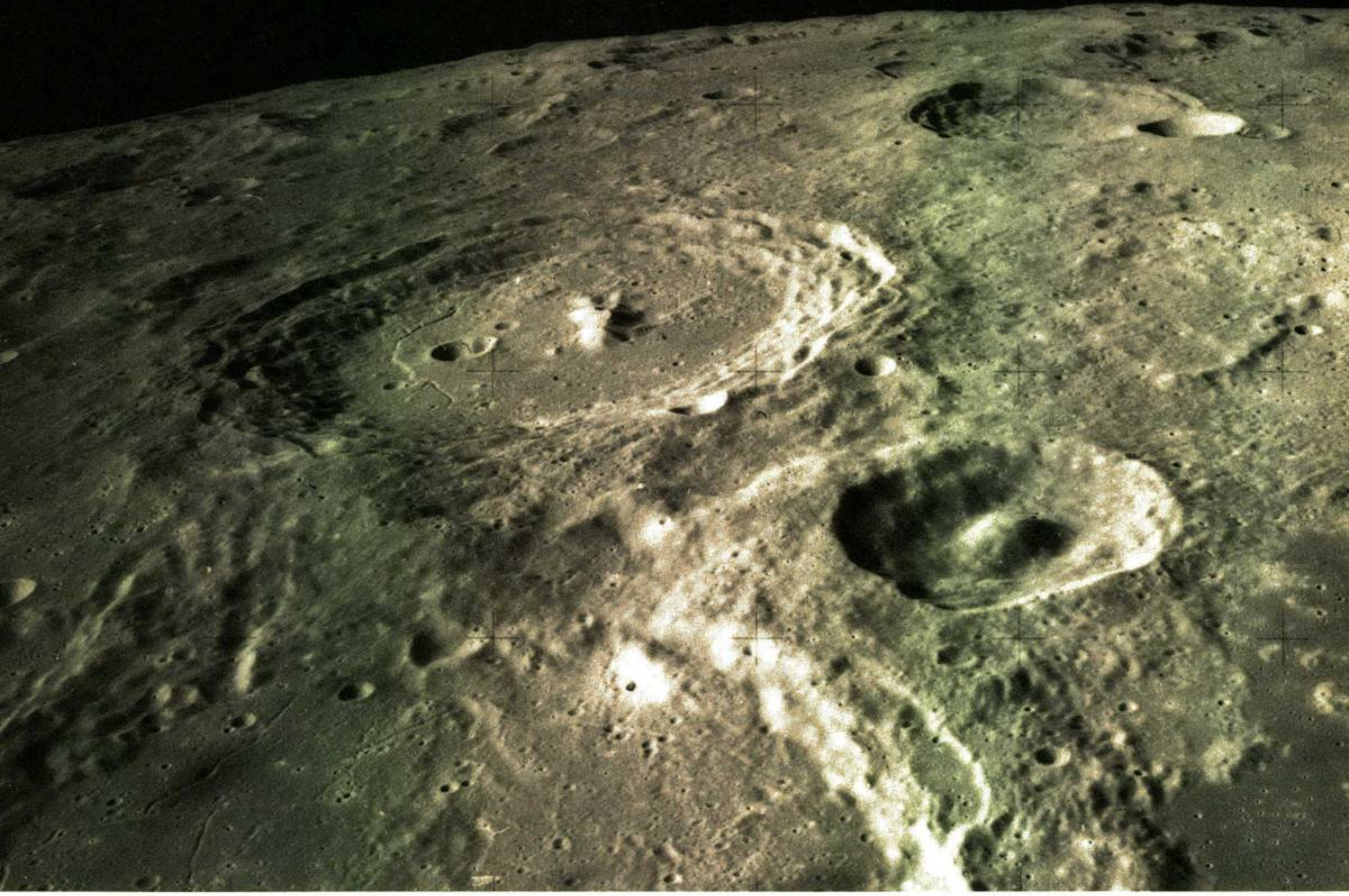
"My view," says McCall, "is that the distances are everything, and the distances have not been absolutely and definitively determined. More work on the distances has got to be done before any of these scenarios can really be regarded as truth.

"But given the distance situation as I presently know it, I think it's possible that at the very least there was a gravitational encounter between galaxies near us and IC 342 and Maffei 1. A more speculative idea is that a merger actually produced the Andromeda Galaxy."

Whatever the case, unraveling the paths of these nearby galaxies proves that not all the frontiers of astronomy lie at the universe's edge — some are right here, in our own galactic backyard. ☐

Ken Croswell is an astronomer living in Berkeley, California, and frequently writes for ASTRONOMY, New Scientist, and Star Date. His last article in ASTRONOMY was "Dance of the Double Sun" in the July 1993 issue.

WHERE THE LUNAR WINDS BLOW FREE



If you stood on the Moon just after sunset, you might notice a faint, almost orange glow on the sunward horizon and overhead. Such twilight glows are familiar to everyone on Earth — but on the Moon? Yet your eyes would not be deceiving you. The glow comes from a trillion trillion sodium atoms fluorescing in the tenuous lunar atmosphere overhead.

That the Moon has an atmosphere is one of planetary science's best-kept secrets. It's easy to see why. The entire lunar atmosphere weighs only about 30 tons and it is recycled and replaced every few weeks. If you compressed it to match the temperature and pressure of the air at Earth's surface, the Moon's atmosphere would fill a cube just 210 feet on a side.

What scientists know about the lunar atmosphere today has been hard-won. The first few clues came from the Apollo orbiters and surface instrument stations in the early 1970s. Then through the diligent work of a handful of planetary astronomers with high-tech spectrometers and imagers, the late 1980s saw a host of fascinating new discoveries. Among these was the realization that the lunar atmosphere is in a real sense the voice of the lunar interior. It is also the divining rod through which mankind may one day determine if there really is water at the lunar poles. Lastly, the lunar atmosphere bears important similarities to the atmospheres of both Mercury and Jupiter's volcanic moon Io.

Old Testament and New

Everyone who's seen the Moon through a telescope can tell it has little or no atmosphere. You see no trace of the familiar effects of our own atmosphere: blue skies, bright clouds, hazes, or auroras. Astronomers from Galileo in the early 1600s down to Viktor Fesenkov and Audouin Dollfus in the mid-20th century used these facts and a host of ingenious observational techniques to prove that if there is any lunar atmos-

It's hardly there at all. But however tenuous, the lunar atmosphere may hold some of the Moon's important secrets.

by Alan Stern

NASA

STARK AND FORBIDDING — but not quite as airless as most people think. The Moon's atmosphere is extremely thin, yet scientists have found it to be a rich brew.

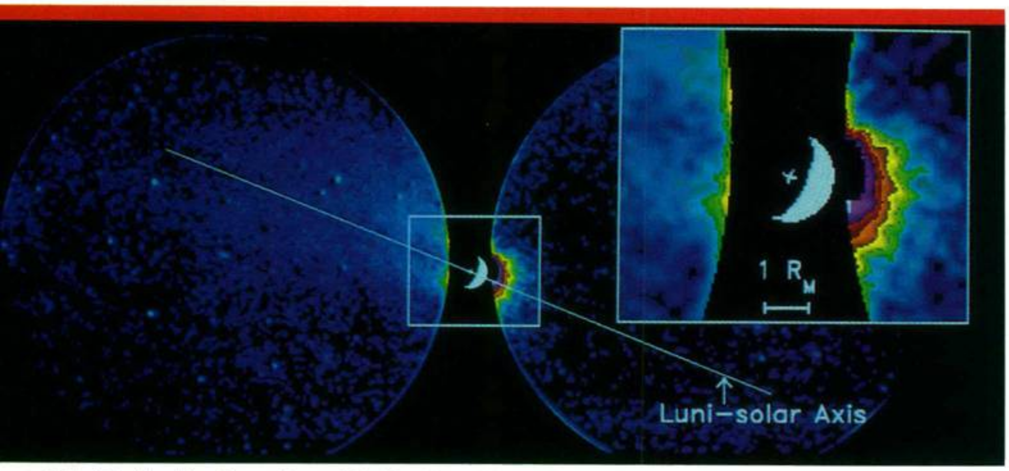
phere, it must be extremely thin. How thin? By the mid-1960s, radio and optical astronomers observing how the limb of the Moon cuts off starlight proved that the pressure of any lunar atmosphere had to be less than $^1/_{10,000,000,000}$ that at sea level on Earth.

With results like that, why keep looking? Because theoretical models said the Moon's feeble gravity should be able to trap and hold at least some of the solar wind, the flow of particles shed by the Sun. Thus when it came time to select instruments for Apollo orbiter investigations and lunar surface experiment packages (ALSEPs), scientists chose no fewer than nine exquisitely sensitive spectrometers and pressure gauges (of five different designs!) to continue the search.

Unfortunately, many of the instruments failed to find any lunar atmosphere. The mass spectrometers aboard the Moon-orbiting Apollo command modules detected only effluents from the spacecraft itself. The ultraviolet spectrometer placed in orbit with Apollo 17 was designed to search almost exclusively for trapped solar-wind gases, like hydrogen, helium, carbon, and xenon. But because its makers bet their design on just a few "likely species," the instrument couldn't detect the very species that scientists now know dominate the lunar atmosphere.

The only orbital instrument that did make a detection, the Apollo 15 and 16 alpha-particle spectrometer, found evidence of small quantities of radon and polonium gas seeping out of the lunar interior; these gases result from the radioactive decay of uranium in the Moon's crustal rocks.

The Apollo surface experiments fared somewhat better. The instruments at the Apollo 12 and 14 sites detected particle densities of up to 100,000 per cubic centimeter at night. And the ion detectors emplaced by Apollos 12, 14, and 15 detected strongly varying particle densities during each 28-day cycle of lunar day and night. This instrument also found evidence that either neon or argon was the principal gas in the atmosphere.



Michael Mendillo, Jeffrey Baumgardner, and Brian Flynn/Boston University Center for Space Physics

LOCAL "COMET" — a cloud of neutral sodium envelops the Moon and flows away downstream in the solar wind.

The most interesting surface results, however, came from the Apollo 17 mass spectrometer, called LACE (for Lunar Atmospheric Composition Experiment). Although LACE operated for only nine months after Apollo 17 left the Moon in December 1972, it made several important findings. First, LACE repeatedly identified both helium and argon. This was the first time scientists were certain they'd identified any volatiles in the lunar atmosphere. Second, scientists discovered the lunar helium concentration rose and fell with changes in the solar wind flow. This fingered the Sun as the source for the lunar helium.

Reports from the Interior

Not all the lunar atmospheric gas is snatched from the solar wind, however. Another important LACE finding was that argon, which peaks each lunar day at over 40,000 per cm^3, seemed to correlate with seismic events instead. This implied that argon, like radon and polonium, was escaping from the lunar interior. LACE also discovered that argon's abundance increased dramatically starting a few hours before each lunar sunrise (see opposite page). Because the surface around the instrument was still in shadow and much too cold to activate the argon when the atmospheric concentration began to increase, the LACE science team concluded the argon was blowing in a gentle wind over the horizon from the just-warming soil on the approaching terminator.

Unfortunately it took more than a dozen years after LACE and Apollo 17 before the next major breakthrough — the discovery of sodium and potassium. These two gases had just been discovered in Mercury's atmosphere by NASA scientists Drew Potter and Tom Morgan; they were confirmed by a University of Arizona group consisting of Ann Sprague, Don Hunten, and Richard Kozlowski. Based on the geological similarities between the Moon and Mercury, both the Potter and Sprague teams eagerly searched for sodium and potassium in the lunar atmosphere.

Sodium and potassium fluoresce very efficiently in the visible part of the spectrum. But to detect the extremely low concentrations of sodium and potassium expected in the lunar atmosphere, both research groups knew they needed large telescopes and sensitive instruments. After several attempts, Potter and Morgan found lunar sodium and potassium using the 2.7-meter reflector at McDonald Observatory in 1987. Ann Sprague and her colleagues also succeeded later that year at Catalina Observatory in Arizona.

To illustrate the technical difficulty of these observations, the sodium concentration they detected was only 67 atoms per cm^3, while potassium was less than 20 atoms per cm^3. To put these numbers into perspective, there are over 10,000 sodium atoms per cm^3 in Mercury's tenuous atmosphere, and *20 billion billion* molecules in each cubic centimeter of air between your eyes and this page.

Having discovered two new lunar atmospheric species, astronomers sought to explore the distribution of these gases. How sodium and potassium atoms vary with altitude provides an important tool for understanding the processes that create the lunar atmosphere. When scientists first investigated the vertical distribution, the results surprised them. The "scale height" of the lunar atmosphere turned out to be much higher than expected.

The scale height is the vertical distance by which an atmosphere's pressure (and usually its density) drop by a factor of about three. Scale height depends on the energy of the atoms and molecules in the atmosphere, so it reveals information about the energetics of the process creating the atmosphere.

Kicking Atoms Around

If the lunar atmosphere is created by Sun-warmed atoms jumping off the surface, the scale height over the day side would be 50 to 100 kilometers. This is because the atoms would have only the energy corresponding to the temperature of the lunar surface, a few hundred degrees. In fact, however, observations by the Sprague and Potter groups show that the scale height of the lunar atmosphere is many hundreds of kilometers, corresponding to atoms moving with temperatures of 1000 to 2000 kelvins.

If the lunar surface heats up to a temperature of only 400 K at noon, what produces temperatures of 1000 K or more? One possibility is a process called sputtering. This occurs when solar photons and solar wind particles strike the lunar surface and liberate atoms and molecules. The solar wind typically has an energy corresponding to a temperature of 1 million to 10 million kelvins. As solar ultraviolet photons or energetic particles bombard the lunar surface, they can knock loosely bound atoms out of crystal lattices in surface rocks and soil grains. After prying an atom loose, some energy remains to give it a kick big enough to excite it to the 1000 to 2000 K temperatures needed to explain the large lunar scale height.

While some scientists have studied the lunar atmosphere's vertical structure, others have examined how it varies across the lunar globe. In a recent pair of studies, groups led by Mike Mendillo of Boston University and me have been making images of the lunar atmosphere. Mendillo, along with collaborators Brian Flynn and Jeff Baumgardner, used a wide-field coronagraph to block the overpowering light from the Moon and to image the whole lunar sodium atmosphere at once. This is an efficient way of determining scale heights and their variations. It is also a good way to map the differences in atmospheric structure from place to place.

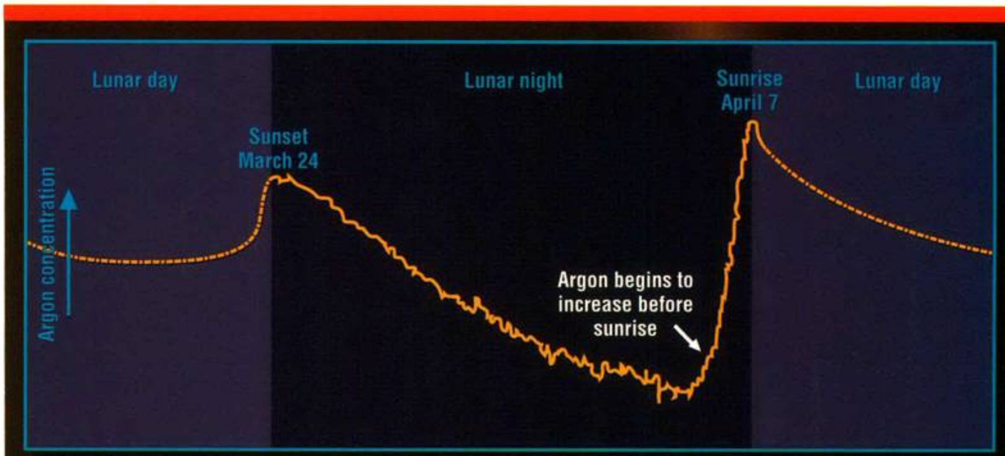
The illustrations on pages 38 and 41 show a lunar atmosphere hardly imaginable even a decade ago. In these images, the Boston University team captured the lunar sodium extending distances of many thousands of miles, enveloping the Moon like a cometary coma. Indeed, more recent images show the extended lunar atmosphere sometimes even develops a tenuous tail much like that of a comet.

The project I am carrying out focuses on much smaller regions of the Moon. The goal is to understand how the atmosphere varies in composition and density from place to place and from time to time. Lunar sodium is dynamic. It's possible that we will find the same kinds of "winds" that the Apollo 17 LACE mass spectrometer found with lunar argon. With both the Mendillo team's wide-field imaging and my high-resolution work, a whole new avenue of exploration is opening up in the study of the lunar atmosphere.

Sounds great. So what's next?

The bigger picture is that planetary scientists want to know how the lunar atmosphere works and how often its gases are swept away and renewed. We want to know if we can use Earth-based observatories to detect emissions from the lunar interior. Imagine sounding the Moon for seismic quakes and gas releases from 250,000 miles away!

We also want to learn whether, since different regions of the Moon have varying surface compositions, the atmosphere above them might also vary in composition. It's possible to ask this because Apollo returned so much accurate information on the mineralogy of the lunar surface. For example, if researchers find higher concentrations of sodium over sodium-rich highlands and the converse above sodium-poor regions, it may be possible to apply that information to Mercury and Jupiter's satellite Io, both of which have sodium and potassium in their atmospheres. In turn we can then begin using atmospheric measurements to discover something about surface composition on these bodies.



FREE AS THE WIND. Apollo 17's mass spectrometer repeatedly detected an argon breeze (arrow) starting to blow hours before local sunrise.

NASA

Eyes on the Prize — Water

Probably the single most exciting question that studies of the lunar atmosphere can help answer is, Does water exist at the lunar poles? The lunar polar water debate has raged for decades and for good reason (see "Search for the Lost Lunar Lakes," March 1993). If water ice exists at the poles — in cold, permanently shadowed regions inside large craters — it would be a bonanza for future scientific and human exploration.

Scientifically, lunar polar water would represent a cache of volatile material ripe for the picking, with the potential to reveal much about the isotopic composition of water brought to the Moon by comets and meteorites. In terms of its importance for human exploration, the discovery of lunar water could provide an important source of hydrogen for fuel, oxygen for rocket-engine oxidizers and breathing, a source of coolants, and even a potentially purifiable source of drinking water for humans, animals, and plants.

Theorists have bandied the likelihood of polar water back and forth since the early 1960s. If you strip the mathematics out of the research papers and reduce them to their main points, the arguments go something like this:

"The polar traps are cold enough to collect water."

"But they are few and far between."

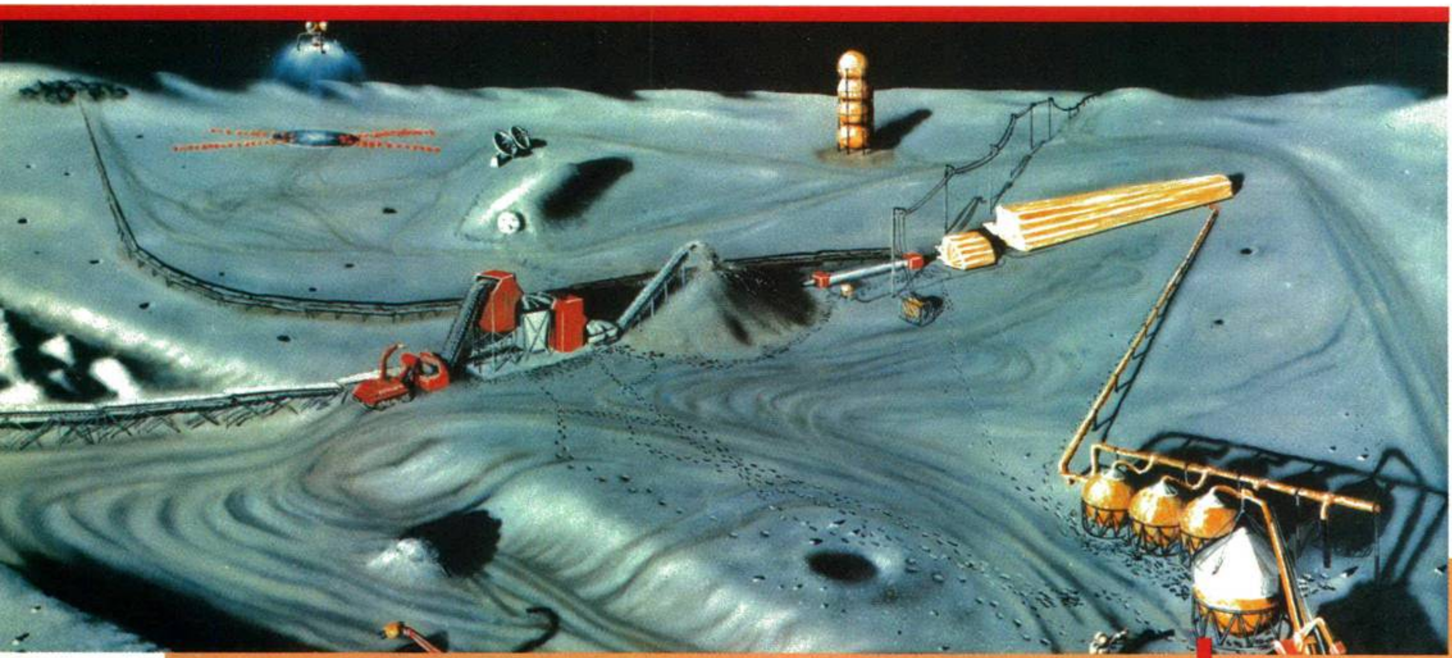
"Yes, but even still there could be thousands of square kilometers of cold traps at the two poles. And water ice is brought to the Moon all the time by comets and some types of meteorites."

"Regardless of the cold temperatures, the solar wind and Earth's magnetotail would erode away deposits faster than they can be created."

"Maybe not. Maybe the frost can be buried by the ejecta splash from micrometeorites faster than it is eroded."

And so on.

With stakes so high, scientists clearly need definitive observations. In 1990 and 1991, Caltech scientists Jim Slade, Dewey Muhleman, and Brian Butler found the first



NASA

A Lunar Wilderness Lost?

SMOKESTACK INDUSTRY? Human exploration and exploitation may change the lunar atmosphere forever.

In the 3.5 billion years since the Moon cooled and largely quit evolving, the lunar atmosphere has probably remained about the way it is today. Of course, there have been occasional large impacts, like the ones that created the craters Copernicus 800 million years ago and Tycho 100 million years ago. These probably injected vaporized debris into the lunar atmosphere. But this material dissipated shortly after each impact. Likewise any volcanism on the Moon may have caused dramatic increases in the mass of the lunar atmosphere, but these too were short-lived.

The fundamental reason gas injected into the lunar atmosphere decays quickly is that sunlight rapidly ionizes its atoms by stripping them of their electrons. Typically, gases ionize in the lunar atmosphere within days or weeks of their release. Once the atoms are ionized, the solar magnetic field lines drive them either down to the surface or into interplanetary space. In either case, the atmosphere loses them.

Looking ahead, however, the pristine wilderness of the lunar atmosphere may soon face its most severe shock ever: human exploration.

With each landing of an expedition, the spacecraft and crew will release tons of fuels and many more tons of gases and wastewater into the lunar atmosphere. Such releases, common during Apollo, were regularly detected by surface instruments left behind by the astronauts. Indeed, each Apollo Moon mission increased the mass of the entire lunar atmosphere by up to 10 tons — or 30 percent. Within a few weeks of each mission, however, the gases escaped and the lunar atmosphere returned to its natural state.

But as we anticipate more extensive exploration of the Moon, it's worth asking how this will affect the Moon's fragile atmospheric environment. With a total mass of only a few tens of tons, it isn't hard to do. Obviously the first impact will be on lunar atmospheric science itself, since the "pollutants" will easily swamp the atmosphere's composition and dynamics.

Richard von Drak of Lockheed's Palo Alto Research Laboratories has modeled the evolution of the lunar atmosphere under various exploration scenarios. Von Drak has found that once the mass of gases released exceeds about 10,000 tons per day, the manmade atmosphere can become thick enough to shield itself from ionizing radiation. After ionization, the next most important cleaning mechanism is atoms warming to the point where their velocity is high enough to escape the Moon's gravity. But this process is much less efficient. If the pollution of the lunar atmosphere ever occurs to the degree envisioned by von Drak, it will become much harder to remove and will be a significant threat to most kinds of lunar astronomy and some aspects of lunar surface science.

Human exploration, lunar science, and the pristine lunar wilderness need not butt heads, however. It's possible that the effluents from lunar bases can be heated to the point where they escape the Moon quickly and never build up. They could also be ionized in an electric arc. And spacecraft traffic could reduce its impact by adopting clean propulsion technologies, like high-power ion thrust.

In any case, one day soon (at least on astronomical timescales), the long-pristine lunar wilderness may become the jurisdiction of someone's EPA.

solid evidence that water-ice may reside at the poles of Mercury. They used radar to detect near-surface patches at the poles whose very high reflectivity is characteristic of ice deposits. Maddeningly, because the Moon lies so much closer to us than Mercury, it's far harder to see into craters at the lunar poles than it is on Mercury. In the absence of radar observations, however, there's another way to answer the question: look at the lunar atmosphere.

If even a thin, transient frosting of water ice (H_2O) resided uncovered at the lunar poles, then some fraction of the H_2O would break up into hydrogen (H) and hydroxyl (OH) as it sputtered off the surface. OH has a characteristic set of emissions in the ultraviolet around 3090 Angstroms. Because Earth's atmosphere almost completely blocks this wavelength, looking for weak OH emissions is very difficult to do from the ground. Unfortunately, the Moon is too bright a target for the Hubble Space Telescope, but a small telescope and an ultraviolet CCD detector in Earth orbit could achieve a very good sensitivity.

If water ice is exposed, then such a telescope should be able to see OH emission above the poles. Such an experiment has never been tried — but one longs to do it. Knowing that there's little or no water ice exposed on the Moon would settle a longstanding scientific problem. At the same time it would tell future lunar base planners whether they can or cannot count on lunar water for their stores. Finding water on the Moon would rival practically any other discovery of the decade and, just perhaps, might ease the way for sending human expeditions back to the Moon.

Scouting the Moon's Atmosphere by 1998?

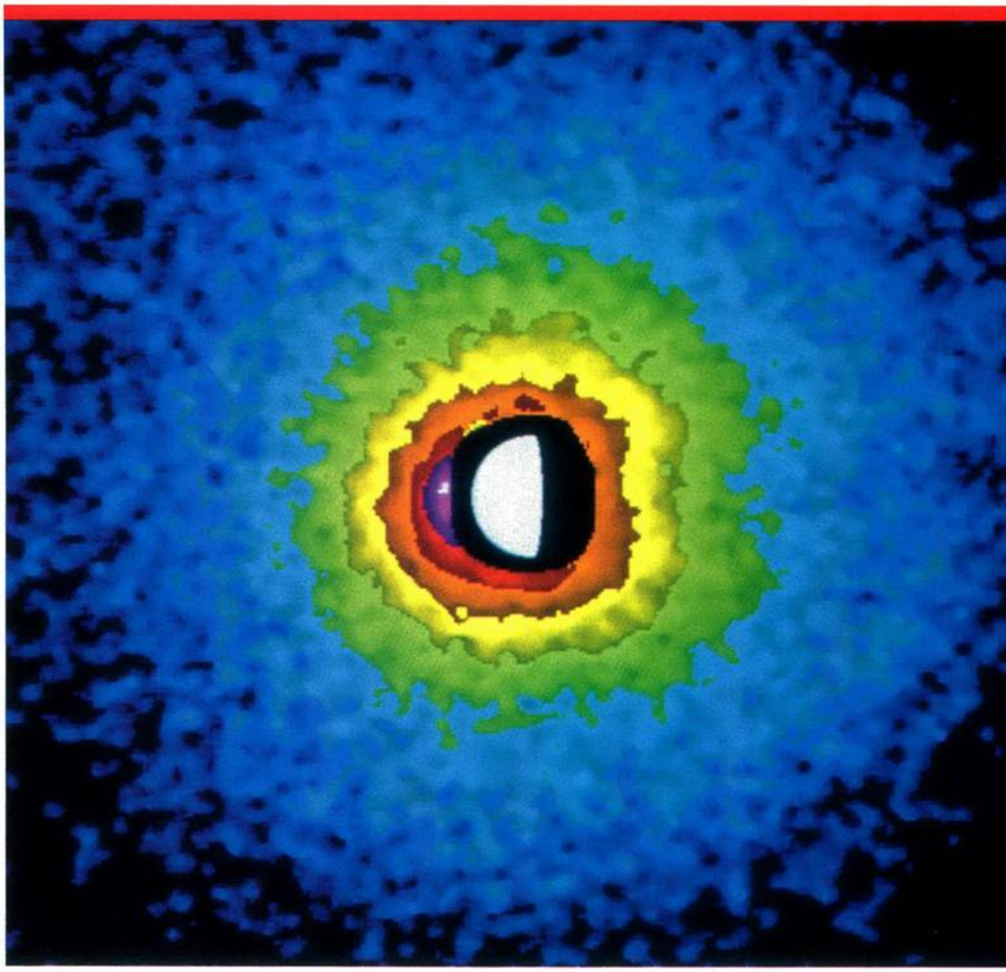
A decade ago Bill Clinton was a young governor, Madonna was still a pretty tame act, and no one believed Apple was a threat to IBM. Republican lawmakers held the Senate, Kevin Costner was just another guy trying to get a hit in Hollywood, and few readers of ASTRONOMY gave thought to the lunar atmosphere. A decade from now — well, who can predict politics and entertainment? Science is a little safer.

Long before 2003 rolls around, NASA may send the first dedicated lunar science missions since Apollo. The Defense Department's Clementine probe will be launched to the Moon in late January 1994, but it contains no instruments to study the lunar atmosphere. However, according to planning for its 1994 budget, NASA is ready to begin a series of lunar science missions called Lunar Scout.

Each Scout spacecraft will be small. And each will carry only a few experiments on a mapping and reconnaissance mission lasting a year or less. The first two Lunar Scouts, which could be launched by 1998, will concentrate on making global mineral and elemental maps of the Moon and on drawing a detailed map of the contours of the lunar surface and lunar gravity field.

Following Scouts 1 and 2, scientists are keen for a mission to study the lunar atmosphere. Such a mission could survey the atmosphere to determine what gases still remain undiscovered, reveal where and at what intervals the Moon is releasing gas, and conduct a search for water so detailed that it could find polar ice ponds smaller than a competition swimming pool.

Will such a lunar atmospheric Scout mission ever fly? I for one sure hope so. Apollo taught us many things about the Moon, and subsequent observations have revealed its tenuous atmosphere to be much more complex and dynamic than we dreamed. Most importantly, we have learned — once again — that Nature is much more interesting than we predicted. ☐



Michael Mendillo, Jeffrey Baumgardner, and Brian Flynn/Boston University Center for Space Physics

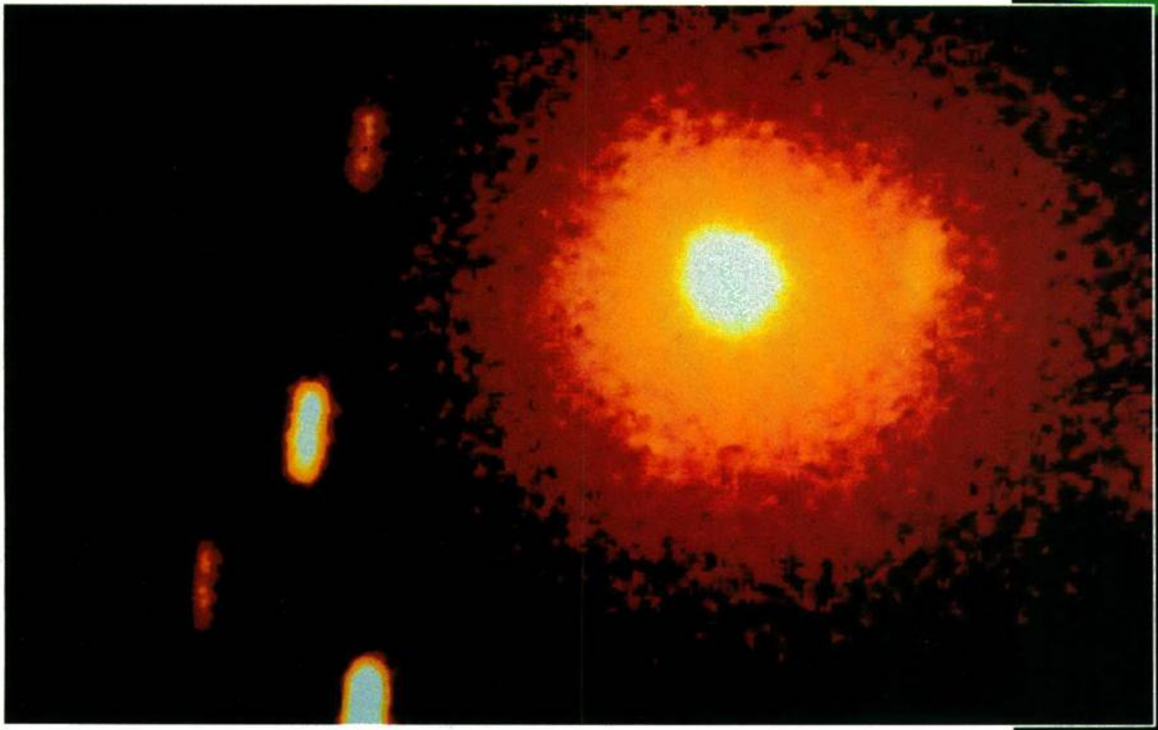
WINDS OF CHANGE. Clouds of sodium around the Moon betray a lunar atmosphere that is restless and dynamic.

Alan Stern is a planetary scientist at the Southwest Research Institute in San Antonio, Texas. His last ASTRONOMY *article was "Where Has Pluto's Family Gone?" (September 1992).*

Close Encounter with a Comet

Six years ago Halley left it battered and blind. But the Giotto probe, sent to a second comet just last year, has confirmed a new model that explains the composition of comets.

by Peter Bond



K. Birkle

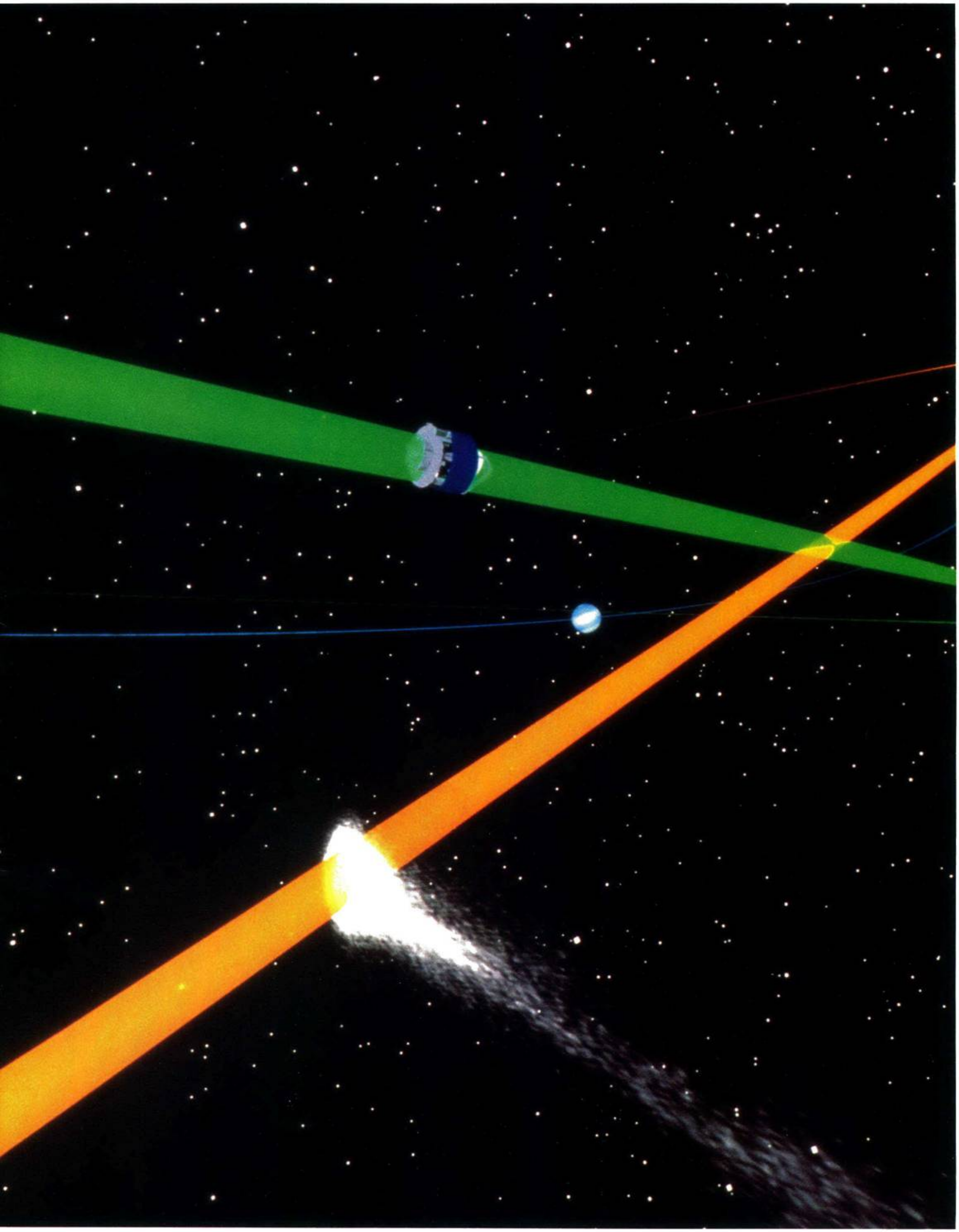
GIOTTO'S SECOND TARGET was the relatively old and inactive Comet Grigg-Skjellerup, seen here in a 1987 ground-based photo.

How do you make a comet? Read any astronomy book from the past few decades and you'll find the recipe: Mix together several kinds of ices, add a dash of dust, and voilà — a comet! Of course this dirty snowball doesn't look like a comet until it approaches the Sun. Only then does sunlight warm the surface enough to vaporize the ices, releasing a cloud of gas and dust to form the comet's familiar coma and tail.

Although this picture squares well with what astronomers observe from the ground, observations made in the mid-1980s from space suggested that dust plays a much bigger role in comets. These observations implied that a comet's nucleus is not so much a dirty snowball as a frozen mudball that holds two or three times more dust than ice.

That's where things stood on July 10, 1992, when the European space probe Giotto encountered Comet Grigg-Skjellerup and wrote a new chapter in the history of space exploration by encountering its second comet. Now, after months of analysis, researchers have released the first

GIOTTO APPROACHES its July 10, 1992 rendezvous with Comet Grigg-Skjellerup. Because the comet (yellow) and spacecraft (green) orbit the Sun in the same direction, the encounter proceeded slowly enough that Giotto got a good view.



ESA

results from the mission. Among the findings: The comet's nucleus sheds matter faster than astronomers previously thought and contains more dust than ice, confirming the frozen mudball picture of comets.

A Trio of Successes

Prior to the flyby of Grigg-Skjellerup, spacecraft had examined only two comets at close quarters. The first was Comet Giacobini-Zinner, explored in 1985 by the American-built International Cometary Explorer (ICE). Although the spacecraft was originally designed to study the interaction between the Sun and Earth, NASA decided to retarget it after six years in orbit. Mission controllers used the Moon's gravity to sling ICE out of near-Earth orbit and direct it toward Giacobini-Zinner.

The spacecraft passed within 8,000 kilometers of the comet's nucleus on September 11, 1985. Its onboard plasma and energetic-particle detectors made the first direct observations of how a comet interacts with the solar wind, the stream of charged particles (mostly protons and electrons) that flows from the Sun. And although dust particles regularly hit the spacecraft, it survived apparently unscathed.

Scientists used the information gleaned from ICE's brief, tantalizing glimpse of Giacobini-Zinner to help plan for the long-awaited return to the inner solar system of Halley's Comet. An international flotilla of spacecraft greeted the famous intruder as it swung around the Sun for the first time since 1910. Although two Soviet Vega spacecraft and two Japanese spacecraft, Sakigake and Suisei, returned a treasure trove of data, the European Space Agency's Giotto was the star of the show.

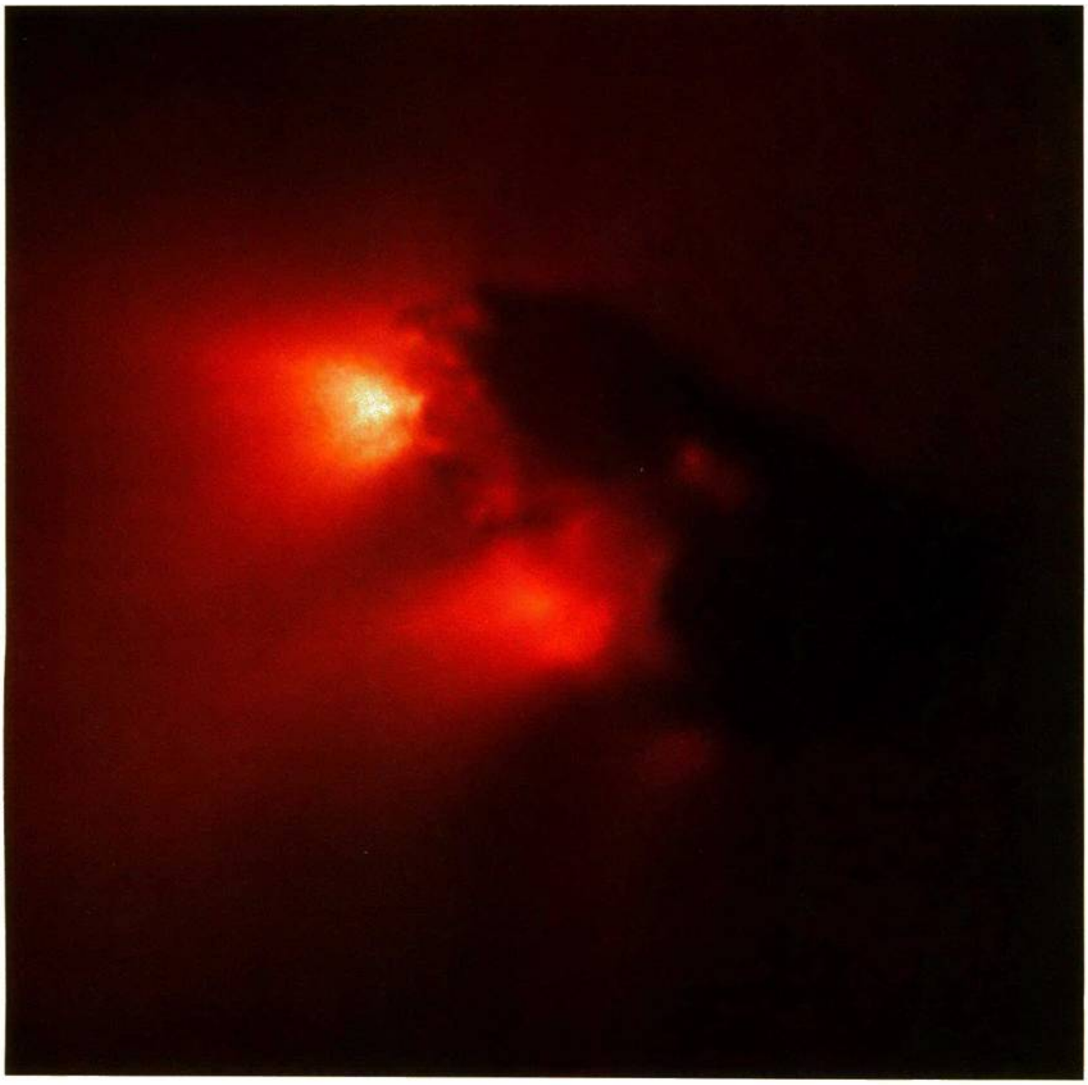
In March 1986, Giotto — Europe's first interplanetary spacecraft — swept past the comet's nucleus at a distance of only 600 km. Not surprisingly, few scientists expected the craft to survive the ordeal, as dust particles traveling fifty times faster than the speed of a bullet continually battered it.

Their fears seemed to have been borne out when the monitor screen at the European Space Operations Center in Darmstadt, Germany, went blank just 15 seconds before closest approach. A "large" dust particle with a mass of about 1 gram collided with Giotto and sent it spinning. More than half an hour passed before mission controllers re-established reliable contact.

Despite this communication breakdown, Giotto's multi-color camera succeeded in sending back the first close-up images of a comet's nucleus. These revealed a potato-shaped object that was significantly larger than expected (16 x 7.5 x 8 km) and marked by ridges, mountains, and depressions on its coal-black surface. Dominating the pictures were three brilliant jets of gas and dust erupting from beneath the dark crust.

At the time of the encounter, Halley was emitting more than 30 tons of material every second. Roughly 80 percent of the cometary gas turned out to be water molecules. Carbon dioxide, carbon monoxide, methane, and ammonia made up most of the rest. Analysis of the dust grains showed two major groups. The organic grains, which included the light elements (hydrogen, carbon, oxygen, and nitrogen), contrasted with those containing the mineral-forming elements such as iron, silicon, calcium, and sodium.

Giotto found that the interplanetary environment surrounding Halley was just as disturbed as that around Giacobini-Zinner. The spacecraft crossed the bow shock, where the supersonic solar wind slows to subsonic speed, 1.15 million km from the nucleus. Much closer in, at a distance



H. Reitsema and A. Delamere (Ball Aerospace)

GAS AND DUST SPEW from jets on the nucleus of Comet Halley, an active comet captured in unprecedented detail when Giotto flew past in 1986.

between 3,600 and 4,500 km, Giotto encountered another boundary, the ionopause. This is where the outward pressure exerted by the gases of the coma balances the inward pressure from the solar wind. When Giotto crossed this threshold, its instruments indicated that a disturbed transition region containing both cometary and solar wind ions changed suddenly to a region of only cometary ions, which flowed smoothly outward.

Following the Halley flyby, ground controllers did a preliminary check of the spacecraft's condition and then put Giotto through a series of major orbital maneuvers to bring it back to Earth. At a cost of using more than half of Giotto's remaining fuel, the maneuvering put the craft in an orbit so it would complete six revolutions of the Sun in the same time that Earth makes five. Thus five years after launch, Giotto would once more return to Earth's vicinity.

Putting Giotto to Sleep

As the spacecraft hibernated, European scientists and politicians debated whether a second comet flyby would return enough scientific data to make such an extended mission worthwhile. Ground controllers reestablished contact with Giotto on February 19, 1990, when the craft was some 96 million km from home. They managed to turn the spacecraft's high-gain antenna toward Earth to increase the signal strength and used the telemetry to check out the instruments.

Considering the pounding Giotto received at Halley, controllers at the European Space Operations Center were pleasantly surprised at the health of their spacecraft. Sadly, one impact apparently knocked the baffle on the color camera so that it blocked the camera's view, preventing it from sending back anymore spectacular images. And damage to the thermal blankets and much of the craft's outer shell caused a marked increase in spacecraft temperature. However, enough fuel remained to maneuver the craft for a second cometary flyby, and seven of its eleven scientific experiments still operated fully or partially.

The opportunity to visit another comet was too good to pass up. European Space Agency member countries were invited to contribute around $12 million, in return for which they would be able to take advantage of a rare, low-cost opportunity to study a comet from close quarters. The Agency approved the attempt in June 1991.

Meanwhile, Giotto completed yet another historic first on July 2, 1990, when it passed within 23,000 km of Earth and became the first spacecraft to use our planet's gravity to change orbit. The gravitational assist flung the spacecraft toward Comet Grigg-Skjellerup to rendezvous almost two years later. Mission control then returned Giotto to hibernation.

Final reawakening came on May 7, 1992, when a whisper from space told ground controllers that the spacecraft was alive and well and responding to commands. At a distance of almost 225 million km, 50 percent farther than the distance between the Sun and Earth, it took the powerful 70-meter-diameter radio antennas of the American Deep Space Network to establish contact with Giotto. The redoubtable explorer was now prepared for a second, possibly fatal, rendezvous with one of the solar system's primeval building blocks.

A Different Kind of Comet

Giotto's two comets could hardly have been more different. Grigg-Skjellerup approaches the inner solar system every five years, whereas Halley's much-trumpeted visits to our skies occur only once every 76 years. The much larger, relatively pristine nucleus of Halley still retains enough icy material to present a magnificent celestial display, complete with a bright, stunning tail. On the other hand, frequent approaches to the fiery Sun have taken their toll on Grigg-Skjellerup, causing it to lose its youthful vigor.

It is much smaller and older in appearance than either Halley or Giacobini-Zinner. Its nucleus — somewhere between 200 meters and 2 km across — is hidden by only a small coma of gas and dust because most of the comet's icy ingredients have long since boiled away. As a result, scientists knew Grigg-Skjellerup's output of gas and dust and its interaction with the surrounding environment (especially with the solar wind) would be much less marked than Halley's.

The nature of the two comets' orbits also influenced the geometry of the flybys. Halley travels around the Sun in a direction opposite to the orbital motion of the planets and of Giotto. As a result, Giotto and Halley hurtled past each other at a velocity of 68 km/sec.

In contrast, Grigg-Skjellerup belongs to a minority group of about 100 comets that orbit the Sun in the same direction as the planets. This means that Giotto was able to overtake its target at the relatively

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STATUS OF GIOTTO'S INSTRUMENTS

CAMERA
aperture blocked — inactive

NEUTRAL MASS SPECTROMETER
detectors dead — inactive

ION MASS SPECTROMETER
one detector active, one inactive

DUST MASS SPECTROMETER
approach geometry poor — inactive

DUST IMPACT DETECTOR SYSTEM
system slightly degraded — active

OPTICAL PROBE
no damage — active

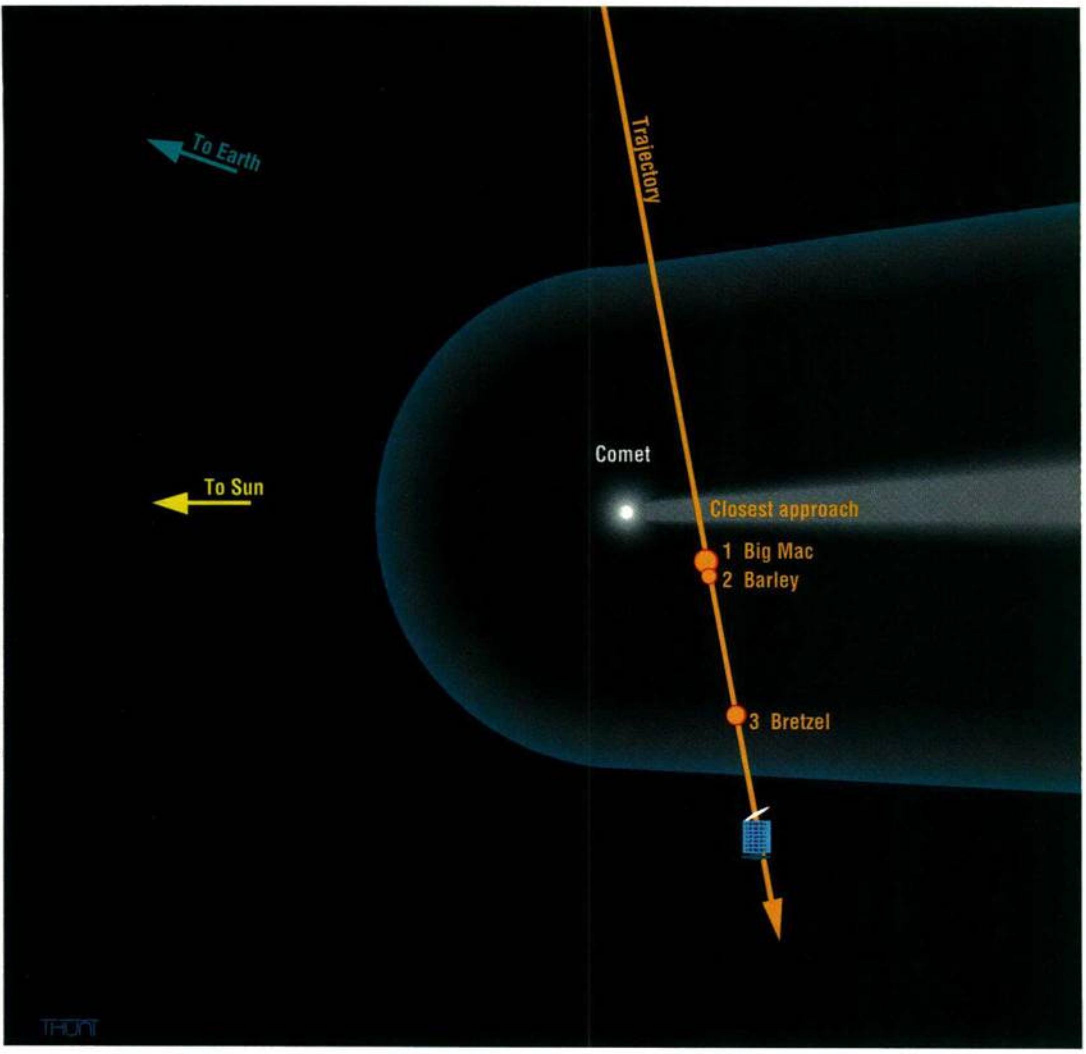
MAGNETOMETER
no damage — active

PLASMA ANALYZERS (JPA)
problems on one sensor — active

PLASMA ANALYZERS (RPA)
damaged — inactive

ENERGETIC PARTICLE ANALYZER
no damage — active

RADIO SCIENCE EXPERIMENT
active



ASTRONOMY: Thomas L. Hunt, after University of Kent at Canterbury

THREE DUST PARTICLES STRUCK Giotto shortly after its closest approach to Grigg-Skjellerup. The particles' large size suggests that the comet's nucleus contains more dust than ice.

leisurely pace of 14 km/sec. While Giotto's path lay fairly close to the ecliptic, the plane of Earth's orbit around the Sun, its target's orbit is inclined 21 degrees to the ecliptic. The encounter took place just a few days before the comet crossed the ecliptic.

Instead of approaching Grigg-Skjellerup with its dust shield facing head-on like a battering ram, Giotto was tilted at an angle of 69 degrees. This allowed the high-gain antenna to point directly toward Earth, ensuring good communications and enabling Giotto to send back its stream of data at a high rate. Also, because its batteries had long since died, Giotto had to be positioned so that the Sun shone vertically onto the solar array. Power was already low because this encounter took place farther from the Sun than the Halley flyby and because the performance of the solar cells had deteriorated. Unfortunately, positioning the spacecraft this way also meant that the dust shield was not oriented optimally for detecting dust particles.

Ground controllers aimed Giotto straight at the heart of the comet. (Although, as project manager Gerhardt Schwehm admitted, the chances of Giotto's colliding with the nucleus were negligible, perhaps a couple in 100,000.) Locating the nucleus wasn't easy, however. Without the use of its eye — the onboard camera system — the blinded spacecraft could not help ground controllers home in on its target. Instead, they had to rely on getting the latest positions of the comet from some of the world's leading observatories.

A Plentiful Supply of Gas

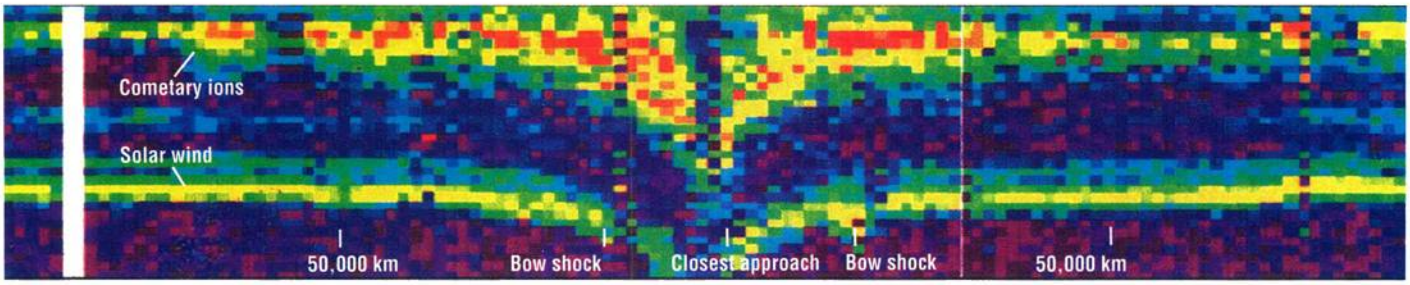
Despite the loss of the camera system, scientists still gained new insights into the nature of Grigg-Skjellerup's coma of gas and dust and the way it interacted with the surrounding space. According to Andrew Coates of Mullard Space Science Laboratory in Surrey, England, Giotto first detected cometary particles at a distance of about 400,000 km. These were distributed in ring-shaped structures that later broadened into the shell-like features also seen at Halley.

At this stage of the encounter, the magnetometer and electron analyzer detected a remarkable series of smooth waves, each about 1,000 km across. This was very different from the turbulence observed at Halley and completely unexpected. As Giotto closed in on Grigg-Skjellerup, the comet's output of ions increased, causing the solar wind to slow down. Near the bow shock, the plasma analyzer detected carbon monoxide and other ions that are heavier than water as well as the expected variety of water ions.

Prior to the encounter, scientists doubted whether they would find a sharp bow shock because of the comet's relatively low activity. However, the spacecraft did cross a less-distinct boundary, labeled a bow wave by the mission scientists, at a distance of about 17,000 km. On the outbound leg of the journey, Giotto crossed the boundary (which was much more noticeable as a bow shock) about 20,000 km from the nucleus. The size of the bow shock suggests that Grigg-Skjellerup produces around three times more gas than astronomers predicted before the flyby, although still a factor of 100 less than Halley.

Counts of charged particles show the cometary ions split into two groups, a transition that is still not understood. Near closest approach, the increasingly dense cometary gas cloud absorbed the incoming energetic ions or changed them into neutral particles. At the same time the magnetic field increased around the nucleus.

To everyone's surprise, despite passing uncomfortably close to the comet's nucleus, the spacecraft came through unscathed. By using the Optical Probe Experiment to determine when the comet appeared brightest, scientists estimate that Giotto flew



University of Kent at Canterbury

TRACE THE COMET'S ENVIRONMENT by following the distribution of ionized gas. Color signifies intensity (red high, purple low) and energy increases toward the top. Note the bow shock 20,000 km from the nucleus, where the solar wind slows to subsonic speeds, and the inner region where no energetic ions exist.

within 200 km of the nucleus. The spacecraft was not overwhelmed by dust particles. The first indication of dust from the coma came at around 17,000 km out, with a marked increase close to the nucleus. According to investigator Annie Chantal Levasseur-Regourd, the amount of dust peaked after closest approach.

Although astronomers could calculate Giotto's time of closest approach to within a few seconds, they could not determine the exact trajectory. The lack of dust indicates that Giotto was not affected by active jets like those seen on Halley, and measurements of the magnetic field suggest that the spacecraft passed on the night side of the nucleus and thus through the comet's tail.

As expected, researchers found Grigg-Skjellerup to be ejecting far less material than Halley. Indeed, Giotto's Dust Impact Detection System recorded only three collisions from cometary dust grains during the entire flyby, all of them after closest approach. The first of these struck about five seconds after closest approach. It was quite large for a dust grain, with a mass of about 100 micrograms. (It was named Big Mac after Professor Tony McDonnell of the University of Kent in England.)

About three seconds later, the much-smaller Barley made contact. (This was named after the barley used to brew the excellent beer at the hotel/brewery used by the science team.) Finally, 40 seconds after Barley struck, came the 20 microgram Bretzel, a name derived from Darmstadt's Bretzelfest — a festival celebrating the pretzel. This last impact coincided with a slight voltage change in a sensor that was so degraded scientists had thought it was inoperative.

Other collisions with dust particles almost certainly took place, but the detection system was unable to sense their arrival. This was partly due to the dust particles' relatively slow speed, which caused them to release only small amounts of energy as they plowed into Giotto. Also playing a role was the spacecraft's crablike approach to the comet, which meant that its dust shield was not aligned favorably to record impacts. (And that's not taking into account the fact that the detectors cover only one quarter of the shield's surface area.) Giotto therefore could not "see" all of the collisions, and mission scientists are convinced that many more took place on other parts of the spacecraft. Of the three events recorded, Big Mac was the only one large enough to partially penetrate the shield.

Nevertheless, according to radio science specialist Martin Patzold, an even bigger impact probably occurred three to four seconds before Big Mac struck. At that moment the spacecraft suddenly changed velocity by 1 mm/second, started rotating slightly faster, and began "wobbling" on its spin axis by 0.08°, which caused the craft to lose radio lock with Madrid for 59 seconds. The wobble eventually died down after about 90 minutes. Patzold suggests that the point of impact may have been on a solar panel close to the radio dish, although there is no evidence of any damage to the solar cells.

Impact of the Big Dust

Although Giotto detected only a few dust particles, they allowed astronomers to draw some important conclusions. The key finding was the relatively large size of the particles. As with Comet Halley, this implies that large dust particles predominate over small ones in these comets and thus the comets lose mass faster and have higher ratios of dust to gas than astronomers used to think.

Levasseur-Regourd has also revealed one other intriguing result that brings into question the nature of Grigg-Skjellerup's nucleus. Two or three "objects" triggered the star mapper about 15 minutes after closest approach. Confident that these were not stars, she suggests that they might be evidence of a split nucleus.

For the 300 scientists and international guests gathered at the European Space Operations Center, the event was a resounding success. Jean-Marie Luton, Director General of ESA, enthused, "Giotto again surpassed all expectations. . . . It is an outstanding example for future collaboration in the peaceful conquest of space."

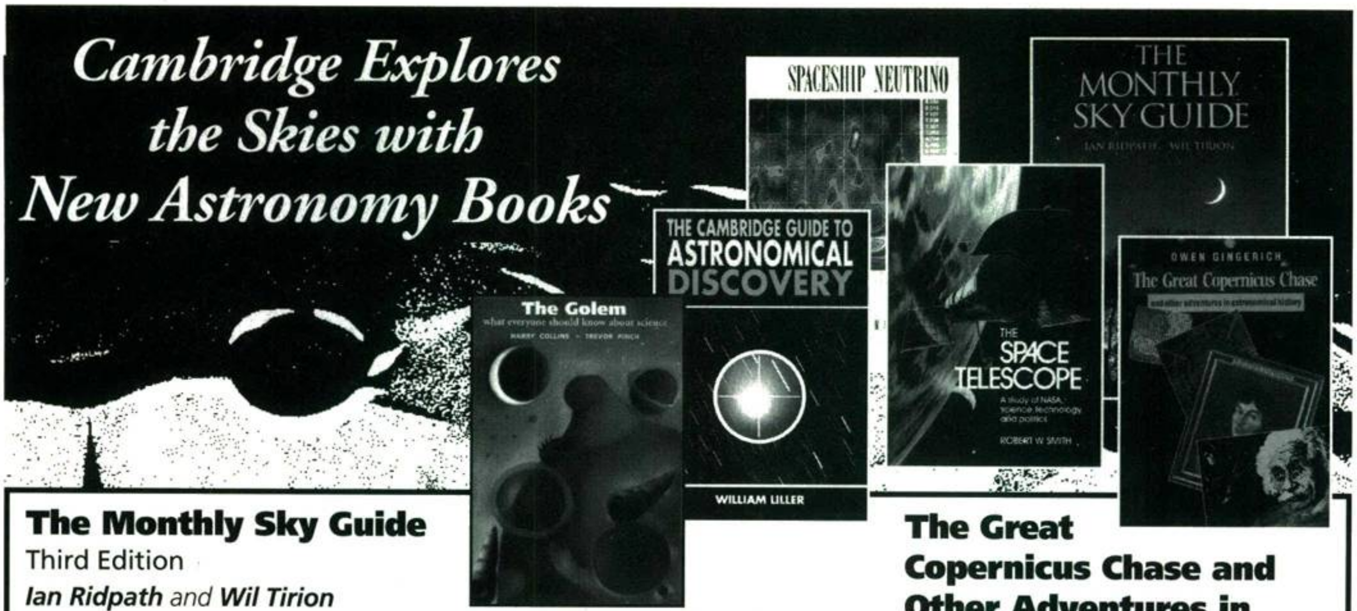
So healthy was the probe after the closest-ever encounter with a comet that scientists initially entertained visions of redirecting the intrepid explorer for a third expedition. However, only 4 kilograms of fuel remained after a final orbital maneuver that ensures its return to Earth's neighborhood.

Giotto's current third period of hibernation will probably be its last. It should make its final bow on July 1, 1999, when it will pass within 220,000 km of our planet, just over half the distance from Earth to Moon. By that time, the craft will be more than 15 years old, and ESA engineers believe that ground station equipment and computers will have changed so much that it may be difficult to communicate with their remarkable space pioneer.

Even though Giotto's active life is over, there is no doubt that the small craft (it weighs only half a ton without its solid propellant) has paved the way for even more ambitious missions. And once again European scientists will be at the forefront of this research. Soon after the turn of the century, scientists hope to send another spacecraft, Rosetta, to land on a comet and bring back a sample for analysis on Earth. That should settle once and for all the question of whether comets are indeed frozen mudballs and not dirty snowballs, a question raised in large part by Giotto's trailblazing. ☐

Peter Bond is a freelance writer specializing in space exploration and astronomy who lives in Sheffield, England.

Cambridge Explores the Skies with New Astronomy Books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Kenneth R. Lang *and* ***Charles A. Whitney***

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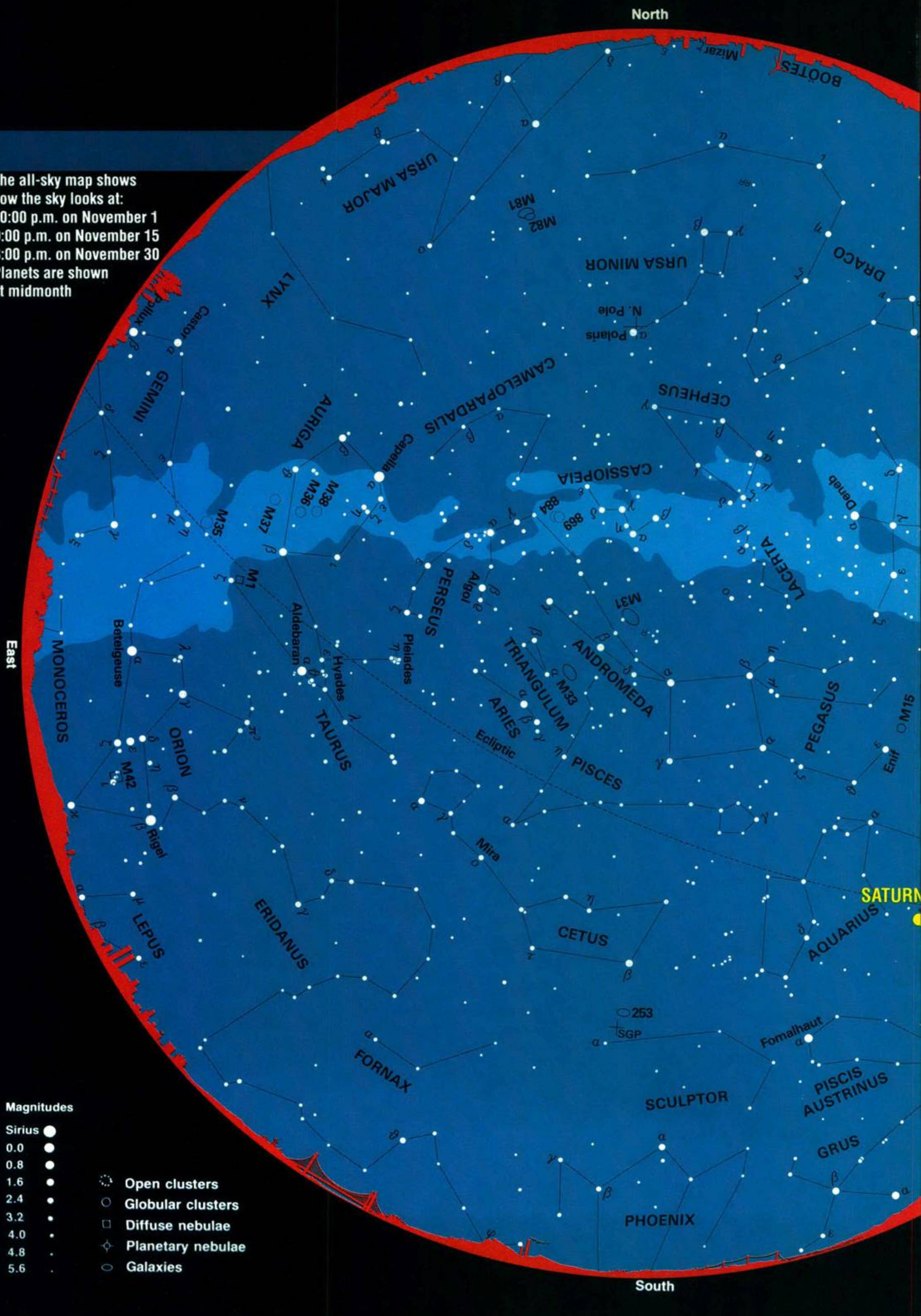
The all-sky map shows how the sky looks at:
10:00 p.m. on November 1
9:00 p.m. on November 15
8:00 p.m. on November 30
Planets are shown at midmonth


North
South
East
URSA MAJOR
M81
M82
Mizar
BOÖTES
DRACO
URSA MINOR
N. Pole
Polaris
LYNX
Pollux
Castor
GEMINI
CAMELOPARDALIS
CEPHEUS
AURIGA
Capella
M38
M36
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M35
M1
CASSIOPEIA
884
869
Deneb
LACERTA
PERSEUS
Algol
M31
ANDROMEDA
TRIANGULUM
M33
ARIES
Ecliptic
PISCES
PEGASUS
M15
Enif
MONOCEROS
Betelgeuse
Aldebaran
Hyades
Pleiades
TAURUS
ORION
M42
Rigel
Mira
LEPUS
ERIDANUS
CETUS
SATURN
AQUARIUS
253
SGP
Fomalhaut
FORNAX
SCULPTOR
PISCIS AUSTRINUS
GRUS
PHOENIX
Magnitudes
Sirius
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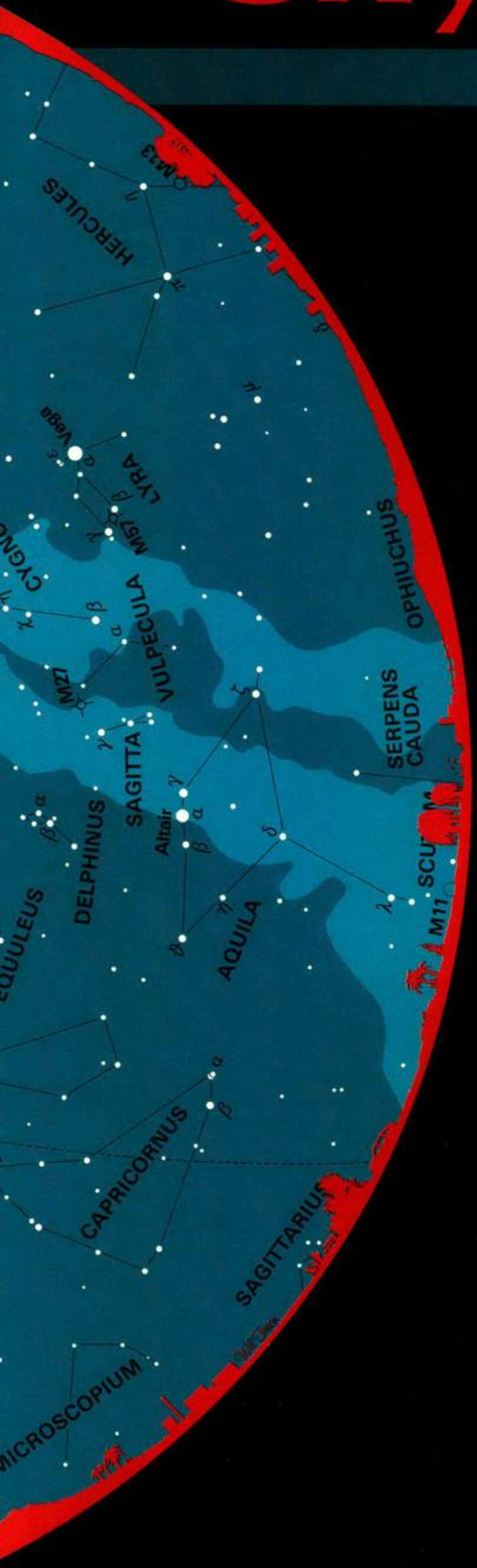
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

November 1993



Map Art by Wil Tirion

- ***Lunar Eclipse Over North America.*** On November 28/29 the Moon slides into Earth's shadow and provides observers in North America with a 48-minute total eclipse. Because the Moon sits between the Pleiades and Hyades clusters in Taurus, the scene will be photogenic for astrophotographers.

- ***Mercury Transits the Sun.*** On November 5 observers in Hawaii and the Western Pacific can witness a rare sky event just before sunset. Tiny Mercury will pass between Earth and Sun, allowing us to see the small planet as a black dot against the Sun's disk.

- ***Unpredictable Leonid Meteors Peak.*** The Leonid meteor shower peaks in a moonless morning sky on November 17. You'll see a dozen meteors per hour, maybe more because the comet that produces the meteors is closing in on Earth.

- ***Southern Solar Eclipse.*** A partial eclipse of the Sun begins at sunrise on November 13 and is visible in the Southern Hemisphere. Eclipse chasers in Australia and New Zealand first see the eclipse. Its ending is visible ten time zones later in South America.

- ***Planets Assemble in Morning Sky.*** November mornings bring a conference of planets and bright stars in the constellation Virgo. On November 11 the Moon hovers near Spica, and below this pair you'll see Jupiter, Venus, and Mercury — a grand gathering!

Calendar of Events

2 Southern Taurid meteor shower peaks at 7 p.m. EST
5 Mercury transits the Sun beginning at 10:06 p.m. EST
Mercury is at inferior conjunction, 10:57 p.m. EST
7 Last Quarter Moon is at 1:36 a.m. EST
8 Venus passes 0.4° north of Jupiter, 12 noon EST
12 The Moon is at perigee (223,781 miles from Earth), 7 a.m. EST
The Moon passes 4° south of Jupiter, 9 a.m. EST
The Moon passes 4° south of Venus, 4 p.m. EST
Northern Taurid meteor shower peaks at 7 p.m. EST
13 New Moon is at 4:34 p.m. EST; partial eclipse
14 Mercury passes 0.7° north of Venus, 8 a.m. EST
17 Leonid meteor shower peaks at 8 a.m. EST
20 First Quarter Moon is at 9:03 p.m. EST
22 Mercury reaches greatest western elongation (20°), 11 a.m. EST
24 The Moon is at apogee (251,842 miles from Earth), 8 a.m. EST
29 Full Moon is at 1:31 a.m. EST; total eclipse

Eye on the Sky

by Deborah Byrd

NIGHT OF THE BLOOD-RED MOON

If you venture outside on November 28/29 and have clear skies you'll see a superb total lunar eclipse, the last such event until April 1996.

Lunar eclipses always occur at Full Moon, when the Moon's orbital motion places it opposite the Sun. In a lunar eclipse the alignment between Earth, Sun, and Moon is so precise that Earth's long shadow brushes the Moon's face.

You can see Earth's shadow any evening. It ascends in the east after sunset and appears as a curved line of darkness set against the deepening blue of the twilight sky. But on November 28, the nearly Full Moon will ascend at the same time as Earth's shadow, also in the east after sunset. Then night will fall and Earth's shadow will be lost against the blackness of the sky, only to reappear again at eclipse time on the face of the Moon.

The eclipse lasts several hours. The Moon enters Earth's barely detectable outer penumbral shadow at 10:27 p.m. EST. Half an hour may pass before you think you can detect the penumbral shadow on the Moon. The real excitement begins at 11:40 p.m. EST on November 29. That's when Earth's dark umbral shadow and the Moon meet. At first, just a tiny dark bite appears on one edge of the Moon. Eighty minutes pass while the shadow of Earth darkens the Moon's face.

Totality begins at 1:02 a.m. EST. The Moon basks in Earth's shadow for 48 minutes, just half as long as it did during the last lunar eclipse on June 4. Totality ends at 1:50 a.m. EST. If you are patient, you can then watch the entire sequence in reverse, until the last vestiges of Earth's shadow leave the Moon at 4:25 a.m. EST.

On the night of the eclipse, the Moon lies between the Pleiades and Hyades star clusters in the constellation Taurus. Also, note the darkness of the shadow on the Moon's face. During a lunar eclipse some sunlight refracts through Earth's atmosphere to find its way onto the Moon's dark surface. So the Moon at mid-eclipse often appears blood red. Several recent eclipses have been very dark red because of the presence of volcanic dust spewed into the stratosphere by Mount Pinatubo, which erupted in the Philippines in June 1991. Has the dust mostly settled now, or will this eclipse be as dark red as the last one?

THE MOON FADES on November 28/29 as it passes through Earth's shadow. This total lunar eclipse will be photogenic because the Moon sits between the bright star clusters the Pleiades and the Hyades in Taurus.

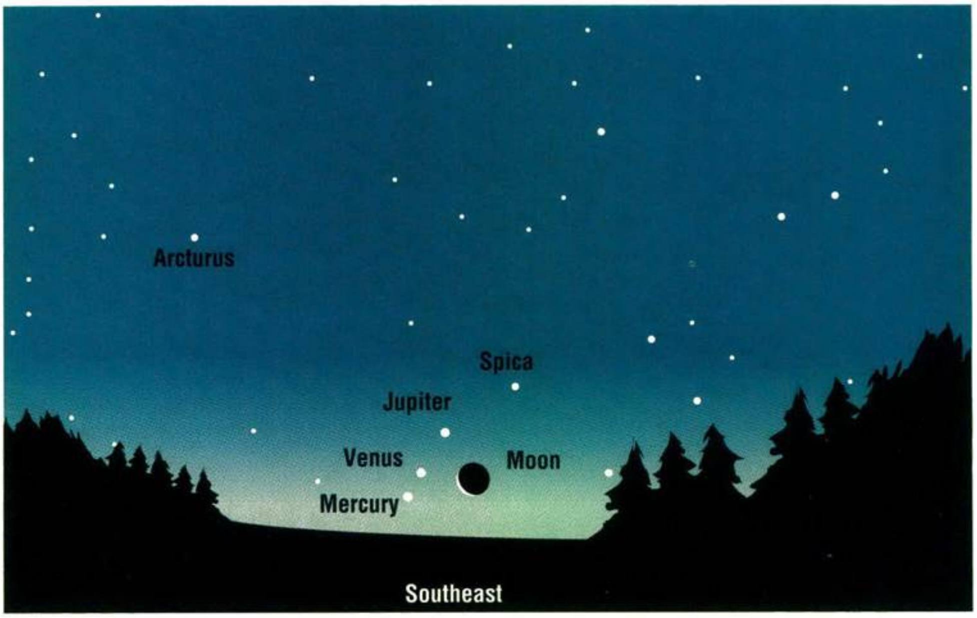
Joe Myers

STORMIN' LEONIDS

Most meteor showers are more like meteor sprinkles, but occasionally lucky observers witness a fabulous meteor storm. In November 1966, on the west coast of North America, people saw more than 100 meteors per *second*. Observers later said they could "feel" Earth's motion through space as these meteors poured from a single point in the sky, their radiant, or apparent origin, in the constellation Leo.

The Leonid meteor shower peaks again this November 17, but no storm is expected this year. The storms come only when the meteors' parent comet, Tempel-Tuttle, approaches the Sun in its 33-year orbit. The comet will return next in February 1998. Still, you may see more meteors than average during this year's Leonid shower. Five years before the last Leonid storm, observers began noticing an increase in the number of meteors.

Leonid activity may be expected to increase in the next few years as Comet Tempel-Tuttle approaches. The Leonids have been producing about a dozen meteors per hour at the peak of a typical shower. This year you might see more. To watch them, go to a dark-sky site on the morning of November 17. Recline comfortably and gaze up at all parts of the sky. With the Moon out of the way, this is an ideal year to watch for these meteors.



PLANETS GATHER in the morning sky during November. On the 12th the Moon, Jupiter, Venus, Mercury, and the bright star Spica are all visible shortly before sunrise.

A GREAT PLANETARY CONJUNCTION

On November mornings be sure to look east before dawn for three planets and the star Spica near this month's waning crescent Moon. The Moon reaches its Last Quarter phase on November 7. Afterward it appears each morning a little closer to the light of dawn, with a smaller fraction of its lighted half facing in our direction. By November 11 it lies just above the star Spica. Below Spica, toward the horizon, you'll see the planets Jupiter, Venus, and Mercury. Jupiter and Venus are very bright and Mercury is somewhat fainter. If you can't spot Mercury with the eye alone, try using binoculars.

Another striking scene comes on November 12, when the Moon is less than two days from New. On this date the Moon appears as a thin crescent that forms a tight cluster with the planets.

NOVEMBER'S PLANETS

When the Sun goes down in early November, **Saturn** comes into view high in the southeast. It arcs across the southern sky all evening and sets shortly after midnight. To the naked eye Saturn looks almost exactly like a star. It's a bit brighter than anything else in its vicinity, but otherwise it's not particularly conspicuous. Still, Saturn is the only planet now visible in the evening sky.

Saturn shines at magnitude 0.7 this month. As time marches on, it loses brightness because Earth is moving away from it in our smaller, faster orbit around the Sun. Saturn is precisely 90° from the Sun — at quadrature — on November 22. Look for it near the Moon on November 19 and 20.

After Saturn sets, the sky is without planets until the brightest planet, **Venus**, rises shortly before the Sun. In the beginning of the month, after you spot Venus low on the eastern horizon in the hour or so before dawn, look closer to the horizon for the sky's second-brightest planet, **Jupiter**. Jupiter has been traveling behind the Sun from Earth, but now it is coming into view again low in the eastern predawn sky. On November 8, Venus lies 0.4° north of Jupiter. By

THE LEONID METEOR SHOWER takes place this year during the dark of the Moon and offers at least a dozen — and maybe considerably more — meteors per hour. Periodically this shower becomes a storm, as it did in 1966. The next storm may come in 1998.

Chick Capen

then you should see both planets with the eye alone. Be sure you are looking toward an unobstructed eastern horizon.

Jupiter shines at magnitude –1.7. Venus is brighter at magnitude –3.9. Venus is about to disappear, however, while Jupiter is getting higher in the sky. By the end of November you can see Jupiter easily as a bright light in Virgo in the eastern predawn sky. Meanwhile, Venus will remain visible throughout this month, but it'll be too low in the sky to see easily.

On November 12, a waning crescent Moon passes near Venus and Jupiter. The bright star above the planets and Moon is Spica in the constellation Virgo. A third planet, **Mercury**, is low in the sky on this date, but it's not as bright as the others. Just a week before this date Mercury transits the Sun, an event visible from Earth's Eastern Hemisphere. During a transit of Mercury the planet moves directly between us and the Sun and observers equipped with telescopes and solar filters can see a tiny black dot crossing the Sun's face.

Mercury moves higher in the predawn sky as November wanes. On November 14, Mercury passes just 0.7° north of Venus. Mercury's greatest elongation comes on November 22 when it is 20° west of the Sun. Mercury is easily visible at this time, below Jupiter in the east before dawn. At greatest elongation, the planet shines at magnitude –0.4.

Mars is not visible this month. It is now traveling behind the Sun as seen from Earth.

THE STARRY SKY

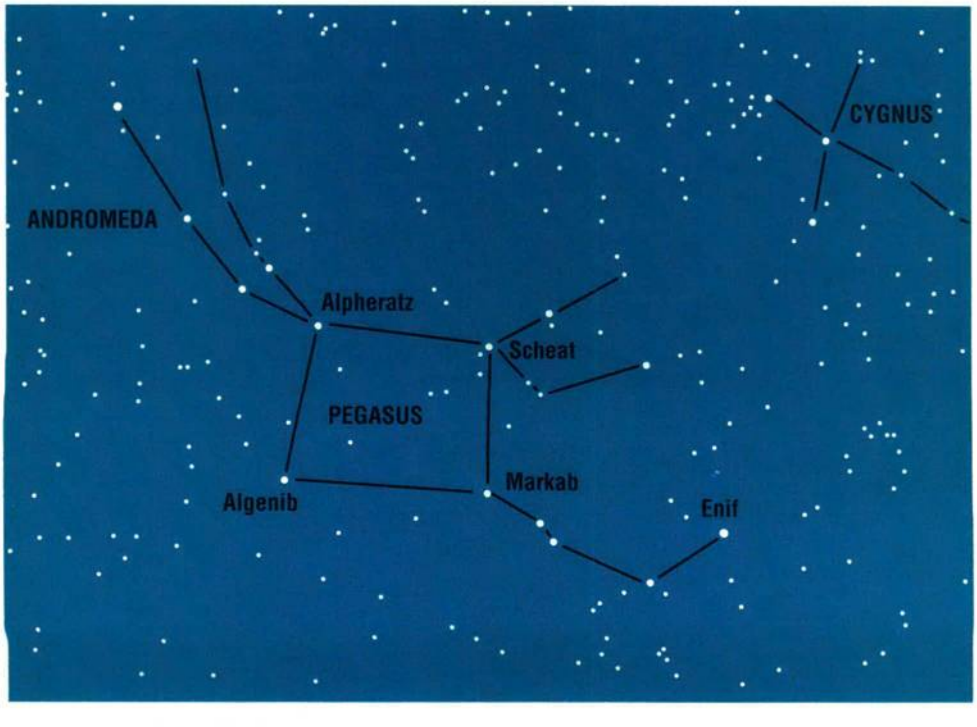
The Great Square in the constellation Pegasus the Winged Horse is one of the sky's most striking star figures. It is a large square, its corners marked by bright stars. You'll find this asterism overhead this month in mid-evening.

The stars in the Great Square are Alpheratz, Scheat, Markab and Algenib. Alpheratz is the brightest of these at magnitude 2.1. Technically this star belongs to the neighboring constellation Andromeda, yet it marks one corner of the Square.

In mythology, Pegasus sprang from the blood of the gorgon Medusa, after the hero Perseus cut off her head. Neptune, god of the sea, caught drops of Medusa's blood and mixed them with sea foam to make a snow-white, winged horse.

Pegasus then belonged to a young warrior named Bellerophon, who took the horse on many adventures. But Bellerophon eventually grew proud. He galloped into the sky on Pegasus to join the gods. Zeus saw him coming and sent a gadfly to sting Pegasus and subsequently throw his rider. Bellerophon fell to Earth where he became blind and lame but Pegasus continued to heaven, where Zeus granted him a place among the stars. □

PEGASUS THE WINGED HORSE consists mainly of a bright, unmistakable asterism called the Great Square. The stars Alpheratz, Scheat, Algenib, and Markab form the square.



Deborah Byrd's daily "Earth & Sky" radio series can be heard on over 450 radio stations.

by Jeff Kanipe

A GRAND LUNAR ECLIPSE

A lunar eclipse visible from North America begins late on the evening of November 28. At mid-eclipse — just after midnight in the central time zone — the Moon is near the zenith for observers in central Mexico. For U.S. observers, it will be just past the meridian as it reaches totality (declination 20°). During totality, the Moon will take on a surreal appearance, a dark orb set among the glittering stars of the Hyades and Pleiades.

The path the Moon takes through Earth's dark shadow, the umbra, makes this one of the more attractive lunar eclipses to view in a telescope or binoculars. Because the Moon's orbit is an ellipse, its distance from Earth varies over the course of the month — and so does the size of Earth's shadow at the Moon's distance. On average, the umbral shadow is about 5,600 miles across at the distance of the Moon. For this eclipse the shadow is about 5,400 miles across.

The Moon's path with respect to the center of Earth's projected shadow also varies, because its orbit is inclined to the ecliptic by about 5°. If the Moon revolved around Earth exactly in the ecliptic plane, we would have lunar and solar eclipses at every Full and New Moon. Most of the time, however, the Moon is above or below the ecliptic plane, so that the Moon passes above the Sun or below it at New phase and above or below Earth's shadow at Full phase. Only when the Moon passes through the ecliptic plane in its orbit (points known as ascending or descending nodes) are we able to see a lunar or solar eclipse.

Even then, however, the geometry is rarely perfect, and this eclipse is no exception. This time the Moon's orbit takes it slightly south of dead center in Earth's umbra. We should expect not to see a uniformly dark eclipse but one in which the Moon is significantly brighter on one side than the other. The southern half, that nearest the penumbra, should be much brighter than the northern half.

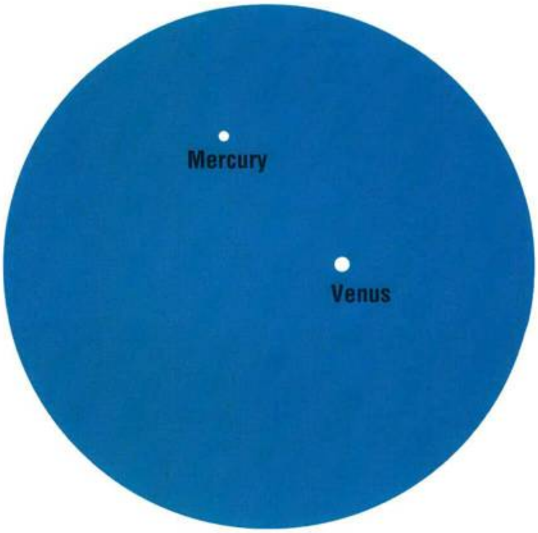
Fred Espenak of NASA's Goddard Space Flight Center predicts this lunar eclipse will be a dark one, though not as dark perhaps as the one in December 1992. Espenak says the umbral shadow has a radial gradient that makes its center much darker than its outer regions. Light rays refracted by Earth's atmosphere into the umbra must travel a longer path in order to reach the inner portions of the umbra. Hence these rays have a greater chance of being absorbed or scattered by the atmosphere.

In contrast, the outer several arcminutes of the umbra, though still much darker than the inside regions of the penumbra, can be fairly bright. Just how bright depends on how much the light rays are attenuated or scattered by atmospheric aerosols (particularly sulfur dioxide from volcanic eruptions) and dust, not to mention cloud cover, which varies around Earth's limb. Just how dark this eclipse will be is really anybody's guess.

You may wish to use your telescope to make whole-disk drawings of each stage of the eclipse. This also helps you evaluate the sharpness and shape of the shadow as well as the visibility of the lunar features.

George Georgiadis

MERCURY TRANSITS THE SUN on November 5. The small black disk of Mercury will slowly move across the face of the Sun over a period of 101 minutes. The event is visible from Hawaii and the western Pacific.



IN THE EARLY MORNING SKY of November 14, bright planets Mercury and Venus are separated by a mere 0.7°. The two dazzling points of light can be viewed in the same binocular or low-power telescope field of view.

While you're at it, try your hand at estimating the visual "presence" of the umbra. A standard method of evaluating the brightness (or darkness) of the eclipsed Moon is a 5-point scale developed by the French astronomer A. Danjon.

Simply put, the observer compares how bright or dark the umbra appears at mid-totality to a list of established observational criteria and from that derives an "L" value. An L value of 0 indicates a very dark eclipse in which the Moon is almost invisible at mid-totality (like last December's). An L value of 1 is a dark eclipse with dark gray or brownish coloration and difficult-to-discern features. L = 2 is assigned to eclipses with deep red or rust hues and a dark central shadow; the outer edge of the umbra should be relatively bright. L = 3 is a "brick red" eclipse; the umbral shadow has a bright, yellowish rim. And an L = 4 is a bright coppery or orange eclipse in which the umbral shadow has an almost bluish appearance.

Observers also use intermediate L values. For example, if the Moon is fairly dark at mid-totality but sports a slightly reddish limb, that would earn an L value of 1.5. This eclipse will no doubt be unusual in its dichotomy of light and shadow, emphasizing again that every lunar eclipse is different and largely unpredictable.

PARTIAL SOLAR ECLIPSE

Earlier in the month a partial solar eclipse traverses an extreme southerly path through the Southern Hemisphere. The eclipse begins at sunrise in Australia and New Zealand, with greatest eclipse occurring two hours later. The event wraps up ten time zones later around sunset in southern Argentina. The maximum amount of the Sun covered by the Moon does not exceed 33 percent in Australia, so expect to see no more than a bite out of the disk.

If you happen to be in the neighborhood of the northern Antarctic coast around 21h45m UT on November 13, you will have the rare opportunity to see a partially eclipsed midnight Sun, the second to occur this year. The previous one was visible in the Arctic region on May 21.

As always, take precautions if you plan to observe this event with a telescope (see below for more information).

MERCURY TRANSITS THE SUN

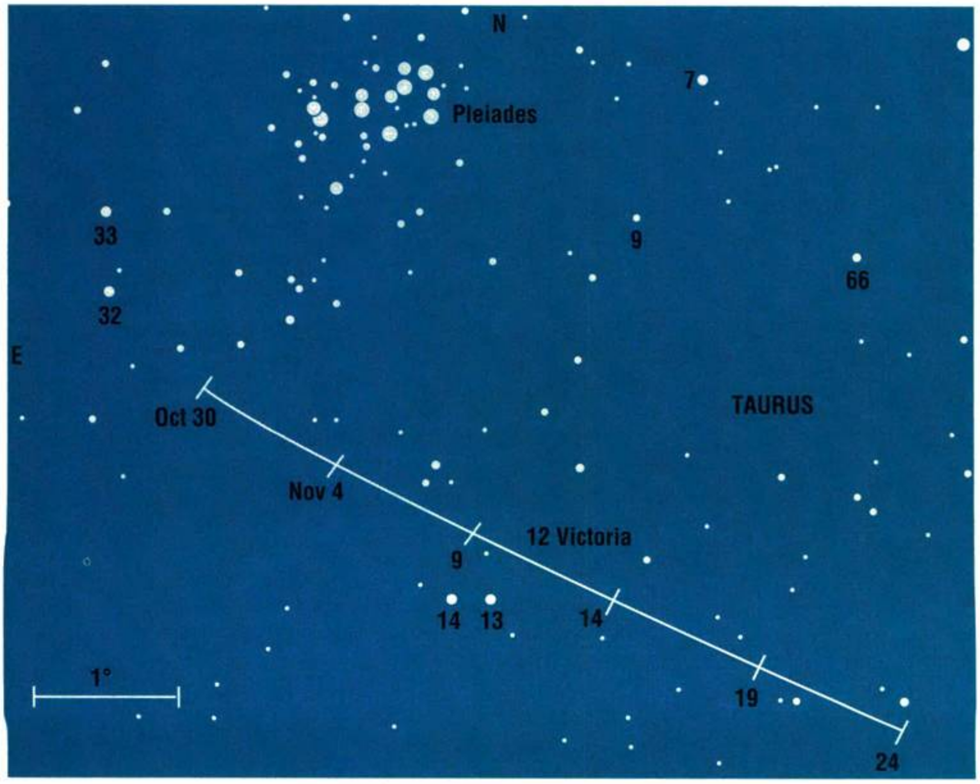
Observers in Hawaii and the western Pacific Ocean will be able to catch Mercury sneaking across the southern edge of the Sun just before sunset November 5.

This transit is closer to being a graze event than a bona fide transit. That is, the farthest Mercury gets from the Sun's limb is 41.5". In Hawaii, the fun begins at 3:57 p.m. and ends as the lower limb of the Sun plunges into the Pacific Ocean around 4:50 p.m. If you're in Australia, however, the Sun will be overhead at mid-transit and can be followed to its conclusion.

COORDINATES FOR 12 VICTORIA

Date	R.A. (2000)	Dec.
Oct. 30	3h53.0m	+21°27'
Nov. 4	3h48.2m	+20°53'
Nov. 9	3h43.0m	+20°18'
Nov. 14	3h37.6m	+19°40'
Nov. 19	3h32.1m	+19°02'
Nov. 24	3h26.9m	+18°25'
Nov. 29	3h22.0m	+17°48'

ASTEROID 12 VICTORIA comes to opposition on November 17, when it shines at magnitude 10.2 and lies in the constellation Taurus.



At the time of transit, Mercury lies over 29 million miles from the Sun and 63 million miles from Earth. Its 3,000-mile diameter yields an apparent angular diameter of about 10". So that's your target, a tiny black disk, smaller than many sunspots, moving just inside the bright limb of the Sun.

Naturally, since you'll unavoidably be looking at the Sun, you'll need to take every precaution against blinding yourself or someone else. As with observing a partial solar eclipse, use mylar or glass over-the-aperture filters or project the Sun onto a shaded screen or card. If you observe using binoculars, you may also use number 14 rectangular welder's glass placed over the telescope's lenses. Do not position the filter at the eyepiece end of the binocular or telescope. The highly focused beam of light could heat and crack the glass. And if you use a filter over only one objective on the binocular, be sure you cap the other one.

Wanda Walker

A PARTIAL ECLIPSE OF THE SUN takes place on November 13 and is visible from Australia, New Zealand, and South America.

ASTEROIDS OF THE MONTH

This month, two asteroids of interest are favorably located for small- to medium-sized telescopes. Both of these objects are located in the Pegasus-Andromeda region, now well up in the east-northeast as darkness falls.

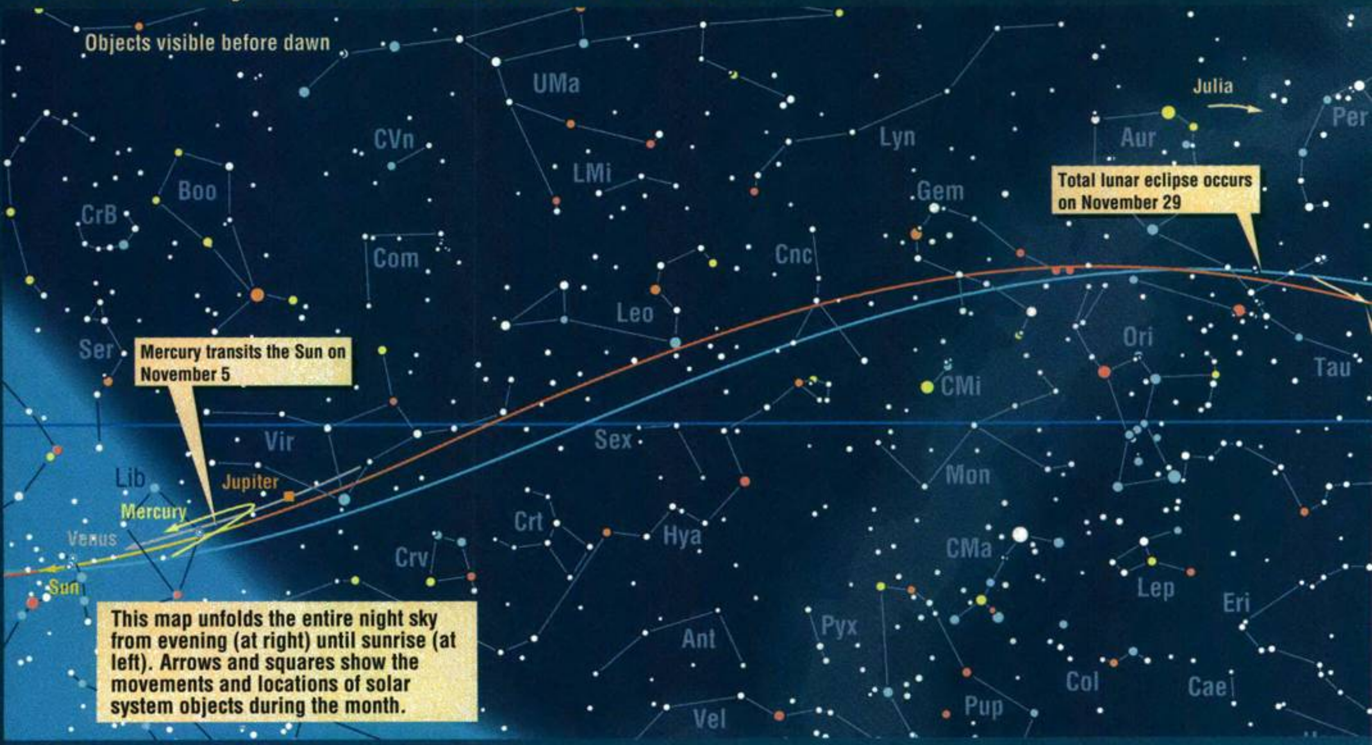
The first to come to opposition is 12 Victoria, an 80-mile diameter siliceous-type (or S-type) asteroid. Victoria reaches opposition on November 17, when it peaks at magnitude 10.2. It can be found in the region south of the Pleiades star cluster in Taurus. Victoria has a fairly slow daily westward (retrograde) motion, so it will remain in this area throughout the month. From about November 9 to 14 the asteroid passes close to the bright stars 13 and 14 Tauri. At magnitude 10.2, however, Victoria may be a little difficult for 2- and 3-inch telescopes, unless your skies are dark. A 6-inch telescope will show the asteroid easily.

Our other minor planet is 89 Julia, also an S-type asteroid, with a diameter of a little under 100 miles. At magnitude 9.8, Julia is somewhat brighter than Victoria, and hence should be easier to find in small telescopes. It reaches opposition December 2. On that day it is located about 3° southwest of Delta Andromedae and forms an almost perfect isosceles triangle with Delta and 28 Andromedae.

When you observe an asteroid, select an eyepiece with a true field of view of no less than a degree. Center the field of view as best you can on the location of the asteroid in the sky and then carefully sketch the star patterns you see in the field on a piece of plain white paper. Come back a night or two later and, using the same telescope and eyepiece, make another sketch to the same scale, but this time use tracing paper. Overlay the tracing paper on your first sketch, matching the star patterns as closely as possible to the previous sketch. The "star" that has shifted position is your asteroid. □

Jeff Kanipe is the editor of Star Date *magazine, which is published by McDonald Observatory at the University of Texas at Austin. He also writes an astronomy column for the Associated Press.*

The Solar System November 1993


Objects visible before dawn
UMa
CVn
LMi
Lyn
Julia
Aur
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CrB
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Gem
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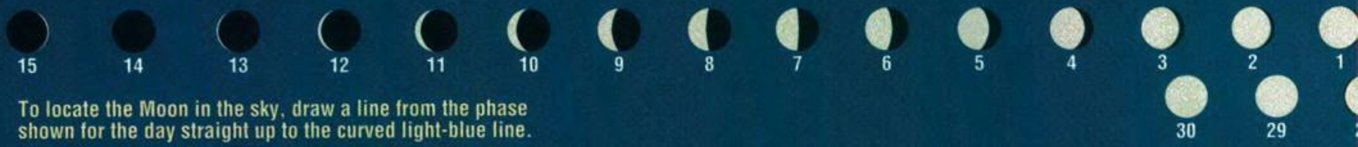
CMi
Vir
Sex
Mon
Lib
Jupiter
Mercury
Venus
Sun
Crt
Hya
CMa
Crv
Lep
Eri
Ant
Pyx
Col
Cae
Vel
Pup

Total lunar eclipse occurs on November 29

Mercury transits the Sun on November 5

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


15
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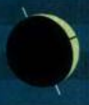
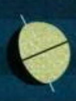
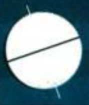
29

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

PLANETS	MERCURY	MERCURY	VENUS	MARS
Date	November 15	November 30	November 15	November 15
Magnitude	0.5	–0.6	–3.9	1.4
Angular Size	8.3"	5.8"	10.3"	3.8"
Illumination	27%	80%	97%	100%
Distance (AU) from Earth	0.807	1.168	1.627	2.452
Distance (AU) from Sun	0.311	0.383	0.721	1.496
Right Ascension (2000.0)	14h19.6m	15h11.3m	14h21.9m	16h08.3m
Declination (2000.0)	–11°43'	–15°57'	–12°45'	–21°24'

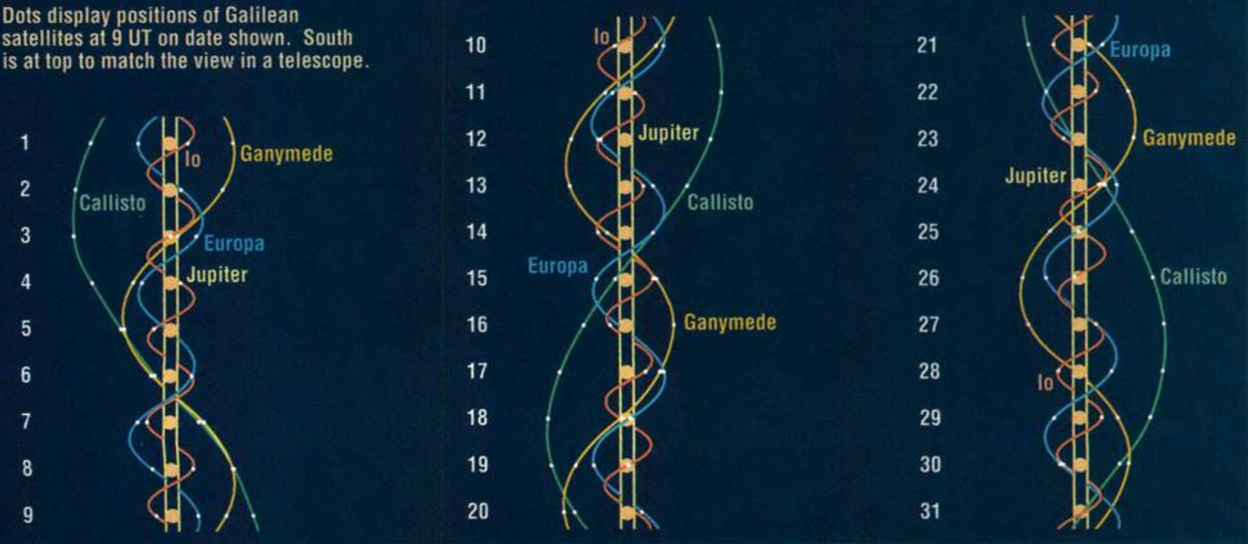






Jupiter's Moons

Dots display positions of Galilean satellites at 9 UT on date shown. South is at top to match the view in a telescope.



From the Editors of ASTRONOMY Magazine

1994 TELESCOPE BUYER'S GUIDE

Celestron
EM-10

A Supplement to ASTRONOMY Magazine

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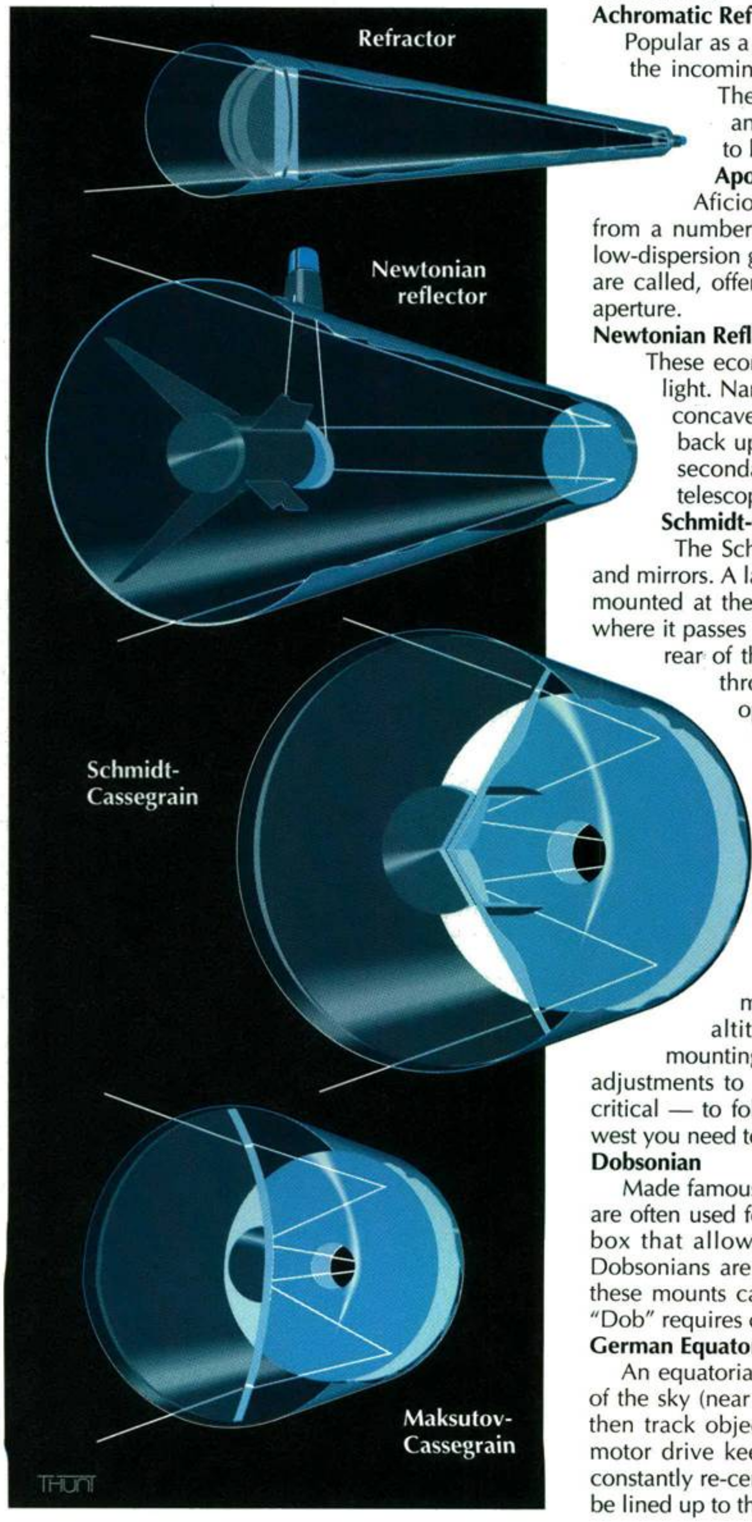
TELESCOPE BASICS

THE OPTICS

Refractor? Reflector? Which is which? A refractor uses a lens to gather light. A reflector uses a mirror. A third class of telescope called a catadioptric uses a mirror plus a lenslike corrector plate. Schmidt-Cassegrains and Maksutov-Cassegrains are both examples of catadioptric telescopes.



Welcome to Astronomy's "1994 Telescope Buyer's Guide!" We've collected the essential specifications of 250 models of telescopes for sale in North America, the largest number ever listed in one place. Our grouping of the many telescopes into similar classes and the side-by-side comparison of specs and prices should help you make a selection. For first-time buyers, we've indicated several classes of telescopes suitable as economical beginners' scopes.

THE OPTICS

Achromatic Refractor

Popular as a telescope for beginners, refractors use a lens to gather and focus the incoming light. The most economical style is the achromatic refractor. These scopes use a lens made of two lens elements that reduce annoying false color (unfocused blue halos around bright objects) to low levels.

Apochromatic Refractor

Aficionados seeking the ultimate in optical performance can select from a number of apochromatic refractors. These instruments use expensive low-dispersion glasses to eliminate the final traces of false color. "Apos," as they are called, offer super-sharp images but can cost $500 to $2,000 per inch of aperture.

Newtonian Reflector

These economical but high-performance telescopes use mirrors to collect light. Named after the design's inventor Isaac Newton, Newtonians use a concave primary mirror at the bottom of the tube that focuses the light back up the tube to a small flat mirror at the top of the telescope. This secondary mirror deflects the light to an eyepiece on the side of the telescope near the top.

Schmidt-Cassegrain

The Schmidt-Cassegrain is a versatile hybrid telescope that uses lenses and mirrors. A large concave mirror gathers the light. A convex secondary mirror mounted at the front of the telescope bounces the light back down the tube where it passes through a hole in the main mirror to focus at an eyepiece at the rear of the scope. As it first enters the scope, however, the light passes through a windowlike lens. This "corrector plate" eliminates an optical distortion called spherical aberration, the flaw that plagues the Hubble Space Telescope.

Maksutov

The Maksutov is like the Schmidt-Cassegrain except that it uses a different type of corrector lens. Commercially made Maksutovs are now available in either Cassegrain or Newtonian configurations.

THE MOUNTING

Altazimuth

Many entry-level refractors and some reflectors come on mounts that allow you to swing the telescope up and down (in altitude) and side to side (in azimuth). The best of these altaz mountings incorporate slow-motion controls that allow you to make fine adjustments to the telescope's position without jarring the telescope. This is critical — to follow celestial objects as they move across the sky from east to west you need to constantly adjust the position of the telescope.

Dobsonian

Made famous by amateur astronomer John Dobson, these altazimuth mounts are often used for large Newtonian reflectors. The tube sits in a wooden cradle box that allows the scope to tilt up and down and swing left and right. Dobsonians are popular because they are so simple and affordable. However, these mounts cannot automatically track the stars. Following an object with a "Dob" requires constantly nudging the mount up or down and left or right.

German Equatorial

An equatorial mount features one axis of rotation aimed at the celestial pole of the sky (near Polaris for Northern Hemisphere observers). The telescope can then track objects by one simple motion around this axis. The addition of a motor drive keeps objects motionless in the eyepiece — there's no need to constantly re-center the object every few seconds. All equatorial mounts need to be lined up to the celestial pole to function properly.

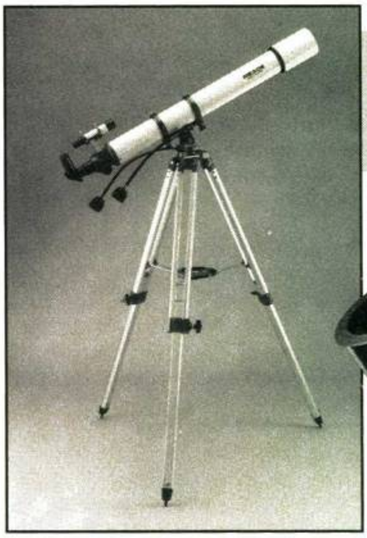
MOUNTS

The mounting is as important a part of any telescope as its optics. Four basic mountings are popular today. The altazimuth and Dobsonian mounts are economical but require constant adjustment to track celestial objects. The German equatorial and fork mountings can track objects but are heavier and more expensive.

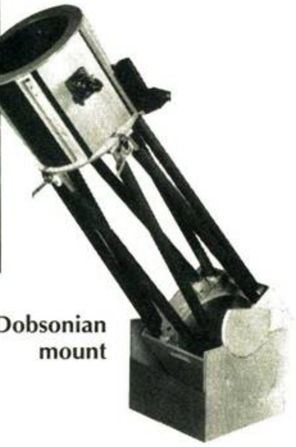
German equatorial mounts (so called because the design was invented in Germany) are distinguished by the counterweights opposite the tube. This style of mount is commonly used on long-tube scopes such as refractors and Newtonian reflectors.

Equatorial Fork

Fork mounts also provide equatorial tracking of celestial targets. They lack the German equatorial's heavy counterweight and are easy to set up and aim. This style is commonly used on stubby-tube scopes such as Schmidt-Cassegrains.



Altazimuth mount



Dobsonian mount

TELESCOPE TERMS

Aperture — The diameter of the telescope's lens or main mirror, measured in inches or millimeters.

Catadioptric — Any telescope that uses a combination of mirrors and lenses. Includes Maksutovs and Schmidt-Cassegrains.

Collimation — Adjusting the position and tilt of a telescope's lenses or mirrors to provide the best image quality.

DC Drives — Motor drives that operate directly from battery packs or car batteries. Other drives use motors that must be plugged into a 110-volt AC source.

Doublet — A refractor lens with 2 elements.

ED Glass — Extra-low Dispersion glass used in premium apochromatic refractors.

Equatorial Table — A motorized platform that when placed under a Dobsonian telescope provides an hour or so of automatic tracking before needing to be reset.

Eyepieces — The small lenses you actually look through. You change magnifications by changing eyepieces. To calculate how much magnification an eyepiece provides, divide your telescope's focal length by the focal length of the eyepiece. Example: a 10mm eyepiece on a 1000mm-focal-length scope will give 100 power.

Finderscope — The small sighting scope that allows you to find and center objects in the main scope. In a designation such as 6x30, the first number is the magnification; the second is the aperture in millimeters.

Fluorite — A low-dispersion lens material used in some apochromatic refractors.

Focal Length — In refractors and Newtonians, the distance from the main lens or mirror to the point of focus at the eyepiece.

Focal Ratio or f/ratio — The focal length of a telescope divided by its aperture. Example: an 80mm scope with a 1200mm focal length is an f/15. As a rule of thumb, fast f/ratio scopes (f/4 to f/6) are better suited for viewing deep-sky objects. Slow f/ratio scopes (f/12 to f/15) are better for viewing the Moon and planets.

Focuser — The device that holds the eyepiece and provides focus adjustment.

Motor Drive — An electric motor added to equatorial mounts to provide automatic tracking. Sometimes called a clock drive.

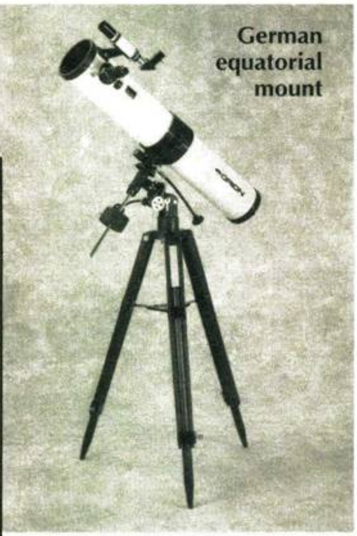
Setting Circles — Graduated dials on the axes of equatorial mounts that aid in finding objects in the sky.

Slow-Motion Controls — Mechanisms for fine adjustment of the position of the telescope.

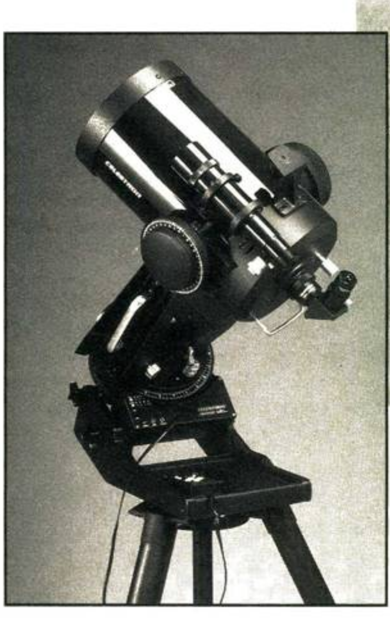
Telrad — A brand of finderscope that produces a red bull's-eye pattern apparently floating in front of the stars.

Triplet — A refractor lens with 3 elements.

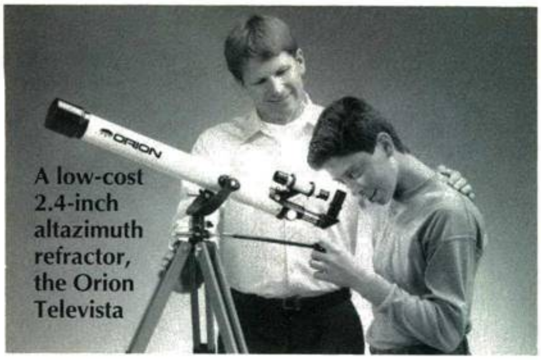
Truss Tube — A style of telescope tube made of break-apart poles. Commonly used on large Dobsonians.



German equatorial mount



Equatorial fork mount



A low-cost 2.4-inch altazimuth refractor, the Orion Televista

ACHROMATIC REFRACTORS

2.4-inch (60mm) Altazimuth Refractors

Parents looking for a telescope for a child often turn to a low-cost 60mm (2.4-inch) refractor. For $150 to $300, a telescope from this class provides the minimum aperture suitable for astronomical use. Look for slow-motion controls on both the up-down and left-right movements, at least a 24mm-aperture finderscope (the "24" in 5x24 — a 6x30 finder is better still), and all-metal and wood construction. Beware of plastic toys, no matter how tempting the price.

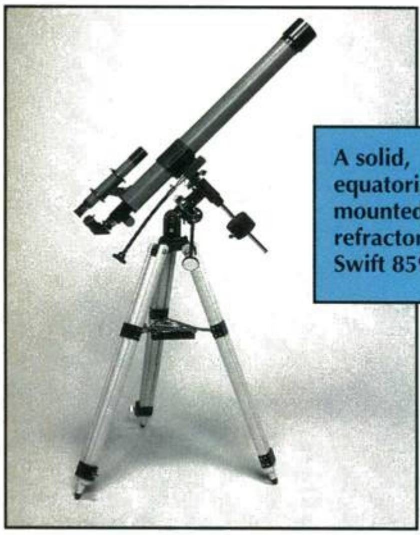
Some manufacturers now offer 60mm refractors with better-grade 1.25-inch-diameter eyepieces. These provide a significant improvement over 0.965-inch-diameter eyepieces included with many small imported refractors.

PROS...

Sharp images; rugged, maintenance-free optics; easily aimed; small scopes suitable for daytime terrestrial viewing; low cost for small apertures.

...and CONS

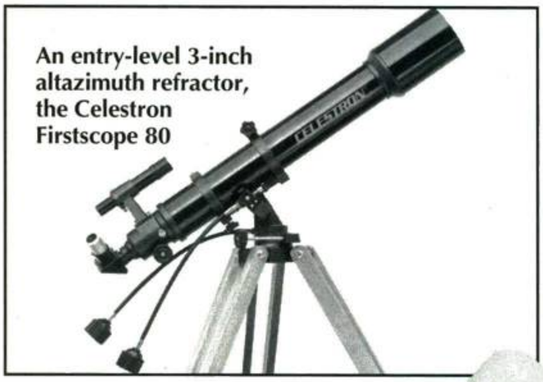
Limited light-gathering power; some false color (worse in large-aperture models); large achromats require long focal lengths and long tubes; expensive for large apertures.



A solid, equatorially mounted 2.4-inch refractor, the Swift 859R

2.4-inch Equatorial Refractors

Several manufacturers offer their 60mm refractor tube assembly on a German equatorial mount with slow-motion controls. These models cost more than the altazimuth version of the same scope ($75 to $250 more, depending on the brand) but provide convenient one-motion tracking of celestial objects as they move across the sky during the night. Some models have electric motor drives available as options. For young children, however, an equatorial mount can be confusing to set up and operate. In all models, look for a 6x30 finderscope and 1.25-inch eyepieces.



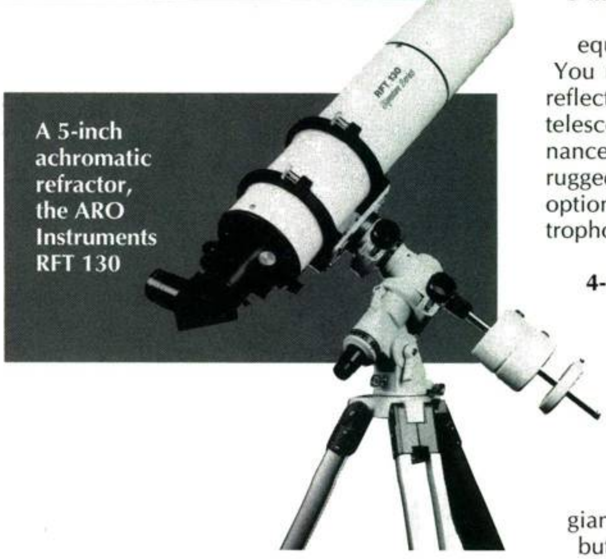
An entry-level 3-inch altazimuth refractor, the Celestron Firstscope 80

3-inch (80mm and 90mm) Altazimuth Refractors

This class of telescope is usually considered the minimum size for "serious" backyard astronomers or for children or teens likely to retain an interest in the hobby. Although more expensive than a 60mm refractor (models start at $500), the 80mm- or 90mm-diameter lens collects twice as much light, providing much brighter, sharper images of all types of objects. The altazimuth scopes from all manufacturers provide good slow-motion controls and good-quality 1.25-inch-diameter eyepieces as standard features. A telescope from this class will serve any beginner well. Even if you move to a larger telescope later, you will find yourself still using your 3-inch refractor now and then for its sheer convenience.

3-inch (80mm and 90mm) Equatorial Refractors

You can buy the same 80mm or 90mm tube assemblies on German equatorial mounts, bringing the price typically to about $600 to $800. You might wonder whether you would be better off with a larger-aperture reflector. Indeed, for this price it's possible to outfit yourself with as large a telescope as a 13-inch reflector. But a 3-inch refractor requires little maintenance, provides sharp, contrasty images, and is easy to set up and use. For rugged portability a 3-inch equatorial refractor can't be beat. Fitted with an optional motor drive, you can use a scope from this class to get started in astrophotography.



A 5-inch achromatic refractor, the ARO Instruments RFT 130

4-inch and Larger Achromats

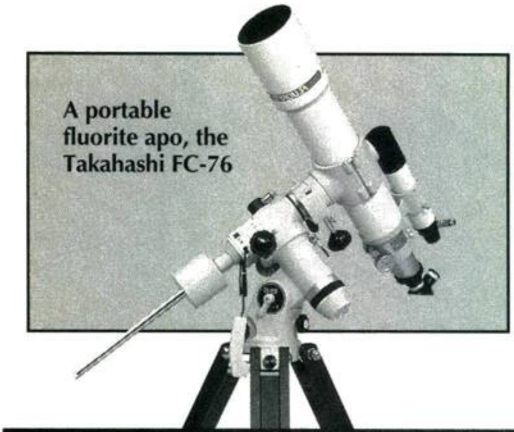
Those looking for an even larger refractor but wanting to stay with the economy and simplicity of a classic achromatic lens can choose from several large-aperture refractors. A 4-inch provides good light-gathering power while still retaining portability. Several manufacturers will custom-make achromatic refractors in sizes as large as 10 inches. Most are f/15 systems — the focal length is 15 times the diameter of the lens. These long focal lengths are necessary to keep false color to a minimum and make for long tube assemblies requiring giant mounts. Big long-focus refractors are excellent for viewing the planets but are not easy to transport.

Manufacturer	Model	Aperture (in.)	f/ratio	Mount design	Drive	Slow motion	Setting circles	Finder	Focuser size (in.)	Average selling price
2.4-inch (60mm) Altazimuth Refractors										
Celestron	C60	2.4	13.3	Altazimuth	—	N	—	5x20	.965	$140
Meade	#227	2.4	11.7	Altazimuth	—	Y	—	5x24	1.25	$199
Orion	TeleVista II	2.4	11.6	Altazimuth	—	Y	—	5x24	1.25	$200
Jason	Rotary #501	2.4	n/a	Altazimuth	—	Y	—	5x24	—	$220
Jason	Compact #319	2.4	n/a	Altazimuth	—	Y	—	5x24	.965	$225
Tasco	#302058	2.4	11.6	Altazimuth	—	Y	—	5x24	.965	$229
Parks	PRT-1	2.4	11.6	Altazimuth	—	N	—	5x24	1.25	$250
Simmons	#6330	2.4	13.3	Altazimuth	—	N	—	5x24	.965	$250
Jason	Rotary #500	2.4	n/a	Altazimuth	—	Y	—	5x24	—	$265
Simmons	#6340	2.4	11.6	Altazimuth	—	Y	—	5x24	.965	$300
Jason	Rotary #338	2.4	n/a	Altazimuth	—	Y	—	5x24	—	$300
Parks	Wide Field 60	2.4	7.6	—	—	—	—	6x30	1.25	$350
Parks	PRT-2	2.4	11.6	Altazimuth	—	Y	—	10x	1.25	$350
Swift	#863	2.4	13.3	Altazimuth	—	Y	—	6x24	.965	$370
Unitron	#114	2.4	15	Altazimuth	—	Y	—	6x24	1.25	$880
2.4-inch (60mm) Equatorial Refractors										
Celestron	C60E	2.4	13.3	German equatorial	—	Y	Y	5x20	.965	$220
Orion	Sky Explorer 60 II	2.4	15	German equatorial	opt.	Y	Y	6x30	1.25	$300
Bausch&Lomb	Telescope 565	2.4	n/a	German equatorial	—	Y	Y	5x24	.965	$310
Meade	#285	2.4	15	German equatorial	—	Y	Y	6x30	1.25	$319
Tasco	#302851	2.4	15	German equatorial	—	Y	Y	5x24	.965	$321
Simmons	#6440	2.4	15	German equatorial	—	Y	Y	5x24	.965	$340
Edmund	#S31-611	2.4	8	Equatorial fork	—	N	N	5x24	1.25	$419
Bausch&Lomb	Professional	2.4	n/a	German equatorial	opt.	Y	Y	10x	.965	$450
Parks	PRT-46	2.4	15.1	German equatorial	opt.	Y	Y	10x	1.25	$450
Swift	#859R	2.4	15	German equatorial	opt.	Y	Y	6x30	.965	$630
Unitron	#128	2.4	15	German equatorial	AC	Y	Y	6x24	1.25	$1,125
3-inch (80mm to 90mm) Altazimuth Refractors										
Meade	#390	3.6	11	Altazimuth	—	Y	—	6x30	1.25	$499
Celestron	Firstscope 80	3.1	11.4	Altazimuth	—	Y	—	6x30	1.25	$540
Unitron	#140	3.0	16	Altazimuth	—	Y	—	6x24	1.25	$1,250
Unitron	#755	3.0	6.6	Altazimuth	—	Y	—	10x42	1.25	n/a
3-inch (80mm to 90mm) Equatorial Refractors										
Orion	Sky Explorer 80 II	3.1	15	German equatorial	opt.	Y	Y	6x30	1.25	$490
Parks	PRT-813	3.1	11.2	German equatorial	opt.	Y	Y	6x30	1.25	$550
Meade	#395	3.6	11	German equatorial	—	Y	Y	6x30	1.25	$599
Celestron	GP-C80	3.1	11.4	German equatorial	opt.	Y	Y	6x30	1.25	$750
Fraunhofer	3.1" Doublet	3.1	15	German equatorial	AC	Y	Y	6x30	1:25	$820
Photon	PIC80	3.1	15	German equatorial	DC	Y	Y	6x30	1.25	$1,250
Unitron	#142	3.0	16	German equatorial	AC	Y	Y	8x30	1.25	$1,950
Unitron	#131 Compact	3.0	16	German equatorial	AC	Y	Y	10x42	1.25	n/a
Unitron	#758	3.0	6.6	German equatorial	AC	Y	Y	10x42	1.25	n/a
4-inch and Larger Achromatic Refractors										
Celestron	GP-C102	4	9.8	German equatorial	opt.	Y	Y	6x30	1.25	$1,250
Photon	PIC100	4	15	German equatorial	DC	Y	Y	7x50	1.25	$2,250
Unitron	#150	4	15	Altazimuth	—	Y	—	10x42	1.25	$2,875
Unitron	#152	4	15	German equatorial	AC	N	Y	10x42	1.25	$3,700
ARO	RFT 130	5.1	5	opt.	—	—	—	—	2.6	$995
D & G	5" Achromat	5	15	opt.	—	—	—	8x50	2.7	$1,295
Fraunhofer	6" Doublet	6	15	opt.	—	—	—	8x50	2	$2,806

Also available: 5" and 6" achromatic refractors and 3" to 6" achromats with folded optics from Photon Instruments; 6", 8", and 10" achromatic refractors from D & G Optical.

Telescopes listed in order of increasing aperture. Telescopes of same or similar aperture listed in order of increasing price. Prices are typical selling prices at full-service dealers; prices may vary from dealer to dealer. n/a = data not available; opt. = optional.

APOCHROMATIC REFRACTORS


A portable fluorite apo, the Takahashi FC-76

A premium 4-inch apo, the Genesis SDF

Small Apo Refractors (2- to 3-inch)

Apochromatic, or "color-free," refractors have become popular premium instruments in the last few years. The light-gathering power of apos in the 2- to 3-inch-size class is limited but their short focal lengths provide low power and a wide field of view, making these little scopes great for scanning large sections of the Milky Way. Apos in this class can also double as spotting scopes for daytime use. If your observing plans call for mostly views of our own planet by day and only casual views of the sky by night, then a small apo will serve you well.

PROS . . .

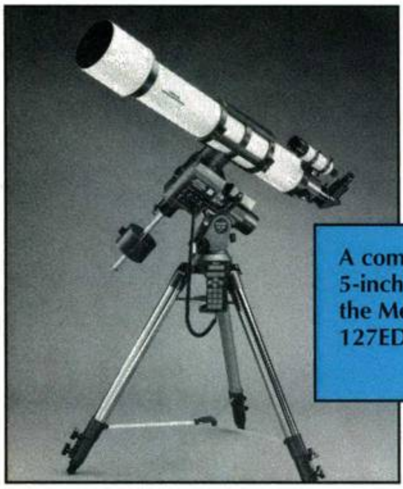
Textbook-perfect images with superb sharpness and contrast; rugged, maintenance-free optics; excellent for astrophotography; small scopes suitable for terrestrial use.

. . . and CONS

Limited light-gathering power; large apos require tall piers and massive mounts; most expensive per inch of aperture of any scope design.

4-inch Apo Refractors

The 4-inch-class size of apo refractor has the most selection of models. These scopes provide good light-gathering power and resolution, are readily adaptable for astrophotography, and are extremely portable. They work well as all-purpose telescopes and are ideal for first-time buyers looking for a top-quality instrument. Even veteran amateurs who have moved up to giant reflectors often find themselves buying a 4-inch apo as a quick-to-set-up second instrument. Refractors in this league also work well as terrestrial spotting scopes.


A computerized 5-inch ED apo, the Meade 127ED

5-inch Apo Refractors

If you want to see more detail on the Moon and planets than a 4-inch scope can provide, a 5-inch apochromatic refractor is a good choice. This size telescope provides brighter images and more resolution than a 4-inch but is still compact and light enough to fit on the smaller mounts offered by several manufacturers. This happy combination keeps cost and weight down and portability up. Fitted with an equatorial mount, a 5-inch apo can be a superb astrophoto instrument and general-purpose scope. It may be all the scope you ever need, providing a level of resolution and contrast to compete with most 6- to 8-inch reflectors and catadioptric instruments.

6-inch Apo Refractors

Backyard observers intent on resolving fine detail on the worlds of our solar system can choose from several outstanding 6-inch-class apo refractors. These instruments provide impressive views of the Moon and planets and work well for viewing deep-sky objects, too. However, apos in the 6-inch size have tubes several feet long and require large mounts to hold them steady. The jump from a 5-inch to a 6-inch apo is a big one, not so much in aperture but in size, cost, and weight of the mount.

Large Apo Refractors

If you are looking for a large planetary and astrophoto telescope for your backyard observatory, you have several 7- and 8-inch apos to select from with prices starting at $5,500. All require massive mounts that can be transported but are best placed at a permanent site.

A compact 6-inch ED apo, the Astro-Physics f/7 155EDT

A SPECIAL CLASS: Solar Telescopes

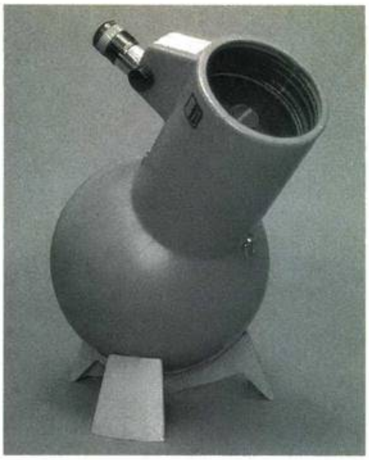
Equipped with a safe solar filter, such as an over-the-aperture Mylar or glass filter, any telescope can be used for looking at the Sun. The two instruments in this special category, however, have been designed specifically for solar viewing. Tele Vue's Solaris is an achromatic refractor while Questar's Solar Observatory is an adaptation of their long-popular Maksutov reflector. Each incorporates a special H-alpha filter that isolates the red light emitted by hydrogen atoms to reveal ever-changing solar prominences and flares invisible through normal white-light filters. H-alpha filters (they cost $1,000 to $2,500) can also be adapted to other telescopes, opening up the fascinating area of solar viewing.

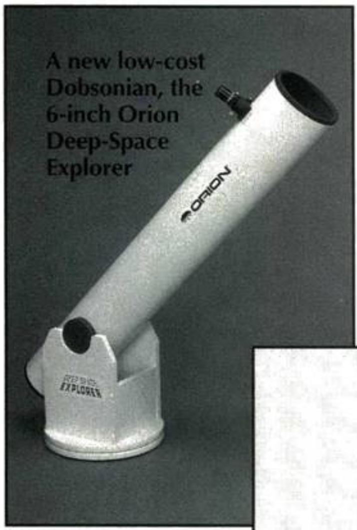
Manufacturer	Model	Aperture (in.)	f/ratio	Lens design	Mount design	Drive	Finder	Focuser size (in.)	Average selling price
Small Apo Refractors									
Takahashi	FC-50SB	2	8	Doublet fluorite	opt.	—	5x25	1.34	$510
Tele Vue	Pronto	2.8	6.8	Doublet ED	opt.	—	opt.	2	$850
Zeiss	AS 80/840	3.1	10.5	Doublet semi-apo	opt.	—	7.5x42	2	$1,500
Takahashi	FC-60SB	2.4	8.3	Doublet fluorite	German equatorial	DC	5x25	1.34	$1,995
Takahashi	FC-76ES	3	7.9	Doublet fluorite	German equatorial	DC	7x50	2	$2,475
Takahashi	FCT-76ES	3	6.4	Triplet fluorite	German equatorial	DC	7x50	2.7	$3,550
4-inch Apo Refractors									
Tele Vue	Genesis	4	5	4-element w/fluorite	opt.	—	opt.	2	$1,650
Tele Vue	Genesis SDF	4	5.4	4-element w/fluorite	opt.	—	opt.	2	$2,000
Meade	102ED Apo	4	9	Doublet ED	German equatorial	DC	8x50	2	$2,195
Celestron	GP-C102F	4	8.8	Doublet fluorite	German equatorial	opt.	6x30	1.25	$2,200
Zeiss	AS 100/1000	4	10	Doublet semi-apo	opt.	—	7.5x42	2.7	$2,300
Cheshire	4" Apochromat	4	13	Doublet ED	German equatorial	opt.	6x30	1.25	$2,700
Zeiss	APQ 100/1000	4	10	Triplet fluorite	opt.	—	7.5x42	2.7	$3,600
Astro-Physics	105 Traveler	4.1	5.8	Triplet ED	German equatorial	DC	opt.	2.7	$3,623
Zeiss	APQ 100/640	4	6.4	Triplet fluorite	opt.	—	7.5x42	2.7	$3,900
Takahashi	FC-100H	4	8	Doublet fluorite	German equatorial	DC	7x50	2.7	$4,720
Takahashi	FC-100NH	4	10	Doublet fluorite	German equatorial	DC	7x50	2.4	$4,825
Takahashi	FCT-100H	4	6.4	Triplet fluorite	German equatorial	DC	7x50	4	$6,185
5-inch Apo Refractors									
D & G	5.1" Apochromat	5.1	9.5	Doublet ED	opt.	—	8x50	2.7	$1,995
Meade	127ED Apo	5	9	Doublet ED	German equatorial	DC	8x50	2	$2,795
Astro-Physics	130 Starfire EDT	5.1	8	Triplet ED	German equatorial	DC	opt.	2.7	$4,641
Zeiss	APQ 130/1000	5	7.7	Triplet fluorite	opt.	—	7.5x42	2.7	$6,500
Takahashi	FC-125NSE	5	8	Doublet fluorite	German equatorial	DC	7x50	2.7	$8,995
Takahashi	FCT-125JP	5	5.7	Triplet fluorite	German equatorial	DC	11x70	4	$12,325
6-inch Apo Refractors									
Meade	152ED Apo	6	9	Doublet ED	German equatorial	DC	8x50	2	$4,495
Astro-Physics	155 Starfire EDT	6.1	9	Triplet ED	German equatorial	DC	opt.	2.7	$6,701
Astro-Physics	155 EDT f/7	6.1	7.1	Triplet ED	German equatorial	DC	opt.	2.7	$7,661
Astro-Physics	155 Starfire EDF	6.1	7.1	Triplet ED w/flattener	German equatorial	DC	opt.	4	$9,921
Zeiss	APQ 150/1200	6	8	Triplet fluorite	opt.	—	7.5x42	2.7	$10,000
Takahashi	FCT-150S	6	7	Triplet fluorite	German equatorial	DC	11x70	4	$27,500
Large Apo Refractors									
Meade	178ED Apo	7	9	Doublet ED	German equatorial	DC	8x50	2	$5,495
Astro-Physics	180 Starfire EDT	7.1	9	Triplet ED	German equatorial	DC	opt.	2.7	$8,699
Zeiss	APQ 200/1600	8	8	Triplet fluorite	opt.	—	opt.	4	$15,000
Astro-Physics	206 Starfire EDF	8.1	7.7	Triplet ED w/flattener	German equatorial	DC	opt.	4	$18,175
Solar Telescopes									
Tele Vue	Solaris	2.4	30	5-element Refractor	opt.	—	—	2	$2,700
Questar	Questar Solar	3.5	14.4	Maksutov-Cassegrain	Equatorial fork	DC	6x	1.25	$6,875

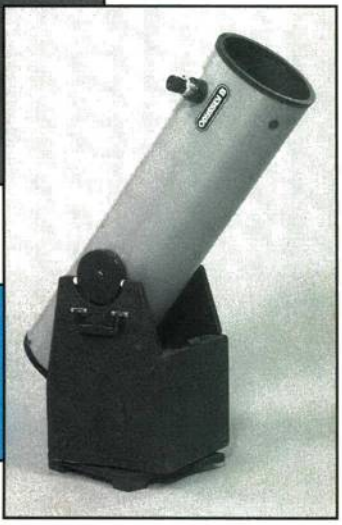
NOTE: All telescopes on this list that include mounts also have slow-motion controls and setting circles.
Telescopes listed in order of increasing aperture. Telescopes of same or similar aperture listed in order of increasing price. Prices are typical selling prices at full-service dealers; prices may vary from dealer to dealer. n/a = data not available; opt. = optional.

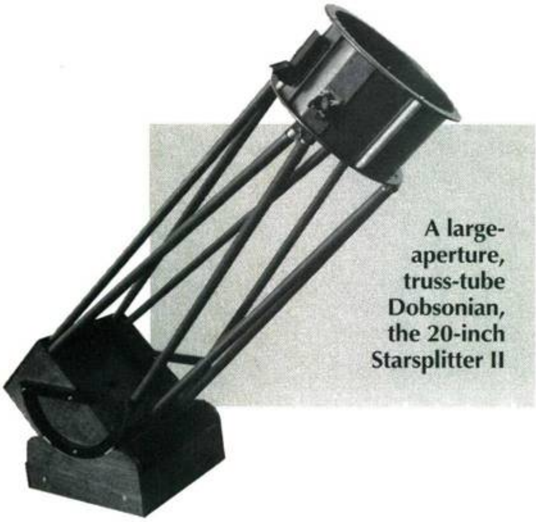
HOW MUCH DOES IT MAGNIFY?

Nowhere in our telescope specifications do you see the magnifications listed. Reading department store catalog ads for 500-power refractors gives many first-time buyers the impression that magnification is critical and the only way to compare telescope performance. But backyard astronomers soon learn that asking "How much does that telescope magnify?" isn't important. The best way to compare telescopes is by comparing aperture — the diameter of the front lens (in a refractor) or main mirror (in a reflector or catadioptric telescope). Line up any group of telescopes and, provided they have comparable optical quality, the telescope with the largest aperture will show more detail. Bigger scopes collect more light (giving them greater "light-gathering power") and focus it into a tinier spot (giving them greater "resolution"). As a result they give brighter, sharper views of the planets and deep-sky objects. But big scopes can cost more and are not as portable. Picking the right scope for you may mean trading off aperture against cost and convenience.


An entry-level reflector, the 4.2-inch Edmund Astroscan


A new low-cost Dobsonian, the 6-inch Orion Deep-Space Explorer


An economical Dobsonian, the Coulter Odyssey 8


A large-aperture, truss-tube Dobsonian, the 20-inch Starsplitter II

DOBSONIAN AND ALTAZIMUTH REFLECTORS

Small Altazimuth Newtonians (3- to 5-inch)

The Dobsonian is the most popular style of altazimuth mounting for reflector telescopes. However, the Vixen and Europtik reflectors come on an altazimuth mount similar to the ones supplied with some small refractors. The Edmund Astroscan, one of the most popular beginners' scopes, has a distinctive ball-shaped base that sits in a tabletop cradle. This 4.2-inch reflector's short focal length makes it best suited for scanning wide areas of the sky, rather than for high-power viewing of the planets.

PROS...

Good-to-awesome light-gathering power; very portable for the aperture; easy to set up; simple to use; lowest cost per inch of aperture of any design.

...and CONS

Occasional collimation adjustments required; exposed mirrors collect dust; no tracking capability (which means no astrophotography); big scopes need tall ladders.

Small Dobsonian Reflectors (6- to 10-inch)

For some of the best values in backyard telescopes, check out Dobsonian reflectors in the 6- to 10-inch size. These $300 to $1,000 scopes feature simple wooden mounts that swing up and down and side-to-side. The generous aperture provides bright images of deep-sky objects and good resolution of planetary detail. The compact size of even a 10-inch model makes it easy to carry the scope outside as a single unit and be observing in seconds. These scopes are simple to use and the low height of the eyepiece is convenient for kids to reach. Be sure to purchase some type of finderscope — it's an essential accessory.

The popularity of scopes in this class does mean a wait for several weeks to months for some models. All must be purchased via mail order.

Moderate-sized Dobsonian Reflectors (12- to 15-inch)

If hunting faint galaxies and nebulae is your main goal, consider nothing less than a Dobsonian reflector from this aperture range. These telescopes provide enough light-gathering power to reveal faint clusters of galaxies yet are still small enough to fit into a compact car for transport to dark-sky sites. To aid portability, many models use a break-apart design with a cylindrical upper end joined to the rocker base with truss poles. The convenient height of the eyepiece, means you can observe without having to climb ladders.

While some very capable economical models are available, this class of scope also includes a number of premium Dobsonians, instruments with beautifully handcrafted mounts and first-class optics. When fitted with high-quality mirrors, Newtonian reflectors aren't just for deep-sky objects. They can also provide superb images of the planets.

Large Dobsonian Reflectors (16- to 20-inch)

Diehard deep-sky fans have flocked to telescopes in this aperture range. Under dark skies, large Dobsonians can reveal just about any object you'll find listed in numerous catalogs and observing guidebooks. To transport one of these big Dobs, you'll need a minivan, station wagon, or pickup truck. You'll also need a ladder to reach the eyepiece, which may be six to eight feet off the ground.

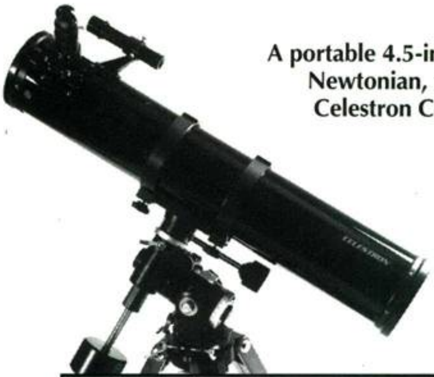
Giant Dobsonian Reflectors (24- to 36-inch)

Telescopes of this size were unheard of a few years ago. Attend any big star party today, however, and chances are someone will have one of these giants on hand. The views are incredible! But transporting a giant Dobsonian requires a trailer or a full-size van. Although the 250-pound scope itself may break down into pieces, the ladder required to reach the eyepiece 10 feet up in the air does not! Photon junkies have some wonderful scopes to pick from in this class but most of us will be content to let someone else bring this class of monster scope to the next star party.

SUITABLE FOR BEGINNERS

Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Finder	# of eyepieces included	Focuser size (in.)	Tube length (in.)	Total weight (lbs.)	Tube style	Average selling price
Small Entry-Level Altazimuth Newtonians											
Europtik	CR 2.6 Cosmotron	2.6	7.7	n/a	—	1	1.25	20	20	Solid	$320
Edmund	Astroscan 2001	4.2	4.2	1.50	—	1	1.25	17	13	Solid	$389
Vixen	Sky Scope R-114	4.5	7.9	1.06	6x24	2	.965	32	20	Solid	$565
Small Dobsonian Reflectors (6- to 10-inch)											
Orion	6" Explorer	6	8	1.20	opt.	1	1.25	48	29	Solid	$299
Coulter	Odyssey 8 f/7	8	7	1.83	opt.	1	1.25	57	59	Solid	$240
Coulter	Odyssey 8	8	4.5	2.14	opt.	1	1.25	36	39	Solid	$275
Orion	8" Explorer	8	6	1.52	opt.	1	1.25	48	39	Solid	$399
Z Optical	8" Z-Scope	8	6	1.83	Telrad	1	1.25	52	51	Solid	$795
Coulter	Odyssey Compact	10.1	4.5	2.60	opt.	1	1.25	46	65	Solid	$345
Orion	10" Explorer	10	5.6	2.14	opt.	1	1.25	56	68	Solid	$599
Z Optical	10" Z-Scope	10	5	2.60	Telrad	1	1.25	53	65	Solid	$995
Moderate-sized Dobsonian Reflectors (12- to 15-inch)											
Orion	12.5" Explorer	12.5	4.8	3.10	opt.	1	1.25	60	85	Solid	$769
Cusick	Starhunter 1	12.5	4.8	n/a	Telrad	—	2	n/a	80	Truss	$1,199
Starstorm	12.5" Dob	12.5	opt.	n/a	Telrad	—	2	n/a	75	Truss	$1,400
Torus	12.5" Dob	12.5	5.6	2.14	Telrad	—	2	72	60	Truss	$1,950
MAG 1	PortaBall 1	12.5	4.8	2.6	Telrad	—	2	65	71	Truss	$2,395
Coulter	Odyssey 1	13.1	4.5	3.10	opt.	1	1.25	58	100	Solid	$575
Sky Designs	14.5" VPT	14.5	4.5	3.10	—	—	2	65	88	Truss	$2,150
Sky Designs	14.5" Ultralite	14.5	4.5	3.10	—	—	2	65	70	Truss	$2,150
Torus	14.5" Dob	14.5	5.5	2.14	Telrad	—	2	76	85	Truss	$2,350
Starsplitter	Starsplitter II	14.5	5	2.60	Telrad	—	2	74	95	Truss	$2,795
Starstorm	15" Dob	15	opt.	n/a	Telrad	—	2	n/a	90	Truss	$1,800
Tectron	15" Dob	15	5	2.14	Telrad	—	2	75	100	Truss	$2,400
Large Dobsonian Reflectors (16- to 20-inch)											
Starstorm	16" Dob	16	opt.	n/a	Telrad	—	2	n/a	100	Truss	$2,000
Torus	16" Dob	16	5.5	2.60	Telrad	—	2	78	100	Truss	$2,850
Starsplitter	Starsplitter II	16	4.7	3.10	Telrad	—	2	76	105	Truss	$3,195
Sunrise	16" Dob	16	5	2.60	Telrad	—	2	n/a	107	Truss	$3,290
Coulter	Odyssey 2	17.5	4.5	4.25	opt.	1	1.25	76	206	Solid	$1,150
Starstorm	18" Dob	18	opt.	n/a	Telrad	—	2	n/a	125	Truss	$2,500
Sky Designs	18" VPT	18	4.5	3.50	—	—	2	77	110	Truss	$2,750
Safari	Safari 18	18	4.5	3.10	—	—	2	70	148	Truss	$3,100
Torus	18" Dob	18	5	2.60	Telrad	—	2	91	120	Truss	$3,450
Starsplitter	Starsplitter II	18	4.5	3.10	Telrad	—	2	81	115	Truss	$3,495
Sunrise	18" Dob	18	5	3.10	Telrad	—	2	n/a	129	Truss	$3,495
Obsession	Obsession 18	18	4.5	3.10	—	—	2	72	95	Truss	$3,895
Starstorm	20" Dob	20	opt.	n/a	Telrad	—	2	n/a	150	Truss	$3,500
Sunrise	20" Dob	20	5	3.10	Telrad	—	2	n/a	149	Truss	$3,695
Tectron	20" Dob	20	5	2.60	Telrad	—	2	100	150	Truss	$3,700
Sky Designs	20" VPT	20	4	4.00	—	—	2	78	150	Truss	$3,850
Starsplitter	Starsplitter II	20	5	3.10	Telrad	—	2	98	170	Truss	$3,995
Torus	20" Dob	20	5	3.10	Telrad	—	2	102	150	Truss	$4,150
Obsession	Obsession 20	20	5	3.10	—	—	2	104	150	Truss	$4,495
Giant Dobsonian Reflectors (24- to 36-inch)											
Starstorm	25" Dob	25	opt.	n/a	Telrad	—	2	n/a	250	Truss	$5,500
Torus	24" Dob	24	5	3.50	Telrad	—	2	115	240	Truss	$7,250
Tectron	25" Dob	25	5	3.50	Telrad	—	2	125	250	Truss	$7,500
Starsplitter	Starsplitter II	24	5	4.00	Telrad	—	2	126	260	Truss	$8,095
Obsession	Obsession 25	25	5	3.50	—	—	2	120	250	Truss	$8,895

Also available: Tectron 30 ($10,000), Starsplitter 30 (price TBA), Obsession 32 ($11,495), and Obsession 36 ($12,995).
Telescopes listed in order of increasing aperture. Telescopes of same or similar aperture listed in order of increasing price. Prices are typical selling prices at full-service dealers or direct from the manufacturer; prices may vary from dealer to dealer. n/a = data not available; opt. = optional.


A portable 4.5-inch Newtonian, the Celestron C4.5

EQUATORIAL REFLECTORS

Small Equatorial Newtonians (3- to 5-inch)

One of the most popular telescopes for beginners has long been a 4.5-inch Newtonian reflector on an equatorial mount. For about $400 to $600, this combination offers good aperture plus the convenience of one-motion tracking of celestial objects. If you are looking for an entry-level telescope for yourself, a spouse, or a child, a scope from this class makes a good choice.

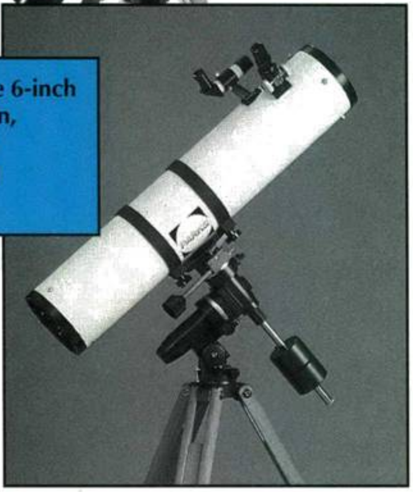
Many of the 4.5-inch reflectors on the market are imported from the Orient and are similar optically, differing only in the accessories and mountings. As with entry-level refractors, look for 6x30 finderscopes and 1.25-inch eyepieces. The ability to add an optional motor drive is important if you wish to try your hand at astrophotography.

PROS...

Excellent light-gathering power and resolution; 6- and 8-inch models quite portable; tracking capability allows astrophotography; low cost per inch of aperture.

...and CONS

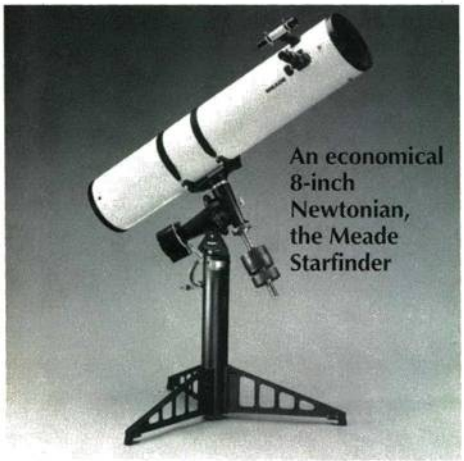
Occasional collimation adjustments required; exposed mirrors collect dust; mountings of large scopes can be heavy and cumbersome to transport and set up.


A versatile 6-inch Newtonian, the Parks Astrolight

6-inch Equatorial Newtonians

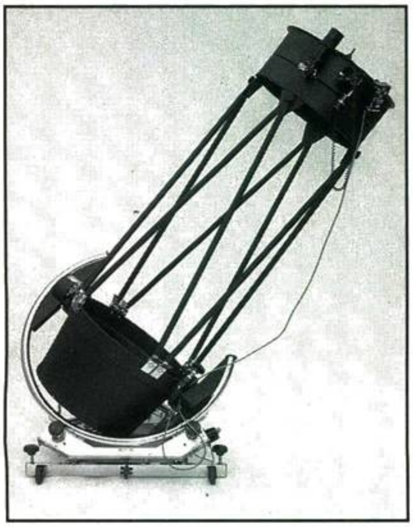
A 6-inch reflector provides images nearly twice as bright as a 4.5-inch does, with a 33 percent improvement in resolution. A Newtonian of this size can be a superb performer, providing sharp planetary views and bright images of hundreds of nebulae, clusters, and galaxies, enough to keep you exploring the sky for many seasons. Ideal as an entry-level scope, a 6-inch Newtonian could also be all the telescope you ever need.

In the last few years, several manufacturers have introduced 6-inch scopes for under $1,000 aimed specifically at the first-time buyer. All are relatively compact — their tubes are about three to four feet long, making them easy to store and carry. All come on traditional German equatorial mounts and most weigh 50 to 70 pounds. Some come with motor drives or have them available as options.


An economical 8-inch Newtonian, the Meade Starfinder

8-inch Equatorial Newtonians

The jump to an 8-inch Newtonian nets you another 75 percent gain in image brightness, bringing in more deep-sky objects and making favorite nebulae and galaxies easier to see. The f/6 f/ratio of most 8-inch Newtonians produces tubes that aren't much longer than many 6-inch f/8 scopes. But the tubes are heavier and larger in diameter. You sacrifice some portability to get the extra light-gathering power. Total weights for scopes in this class range from 60 to 190 pounds.


A big but portable equatorial Newtonian, JMI's NGT 18

10-inch Equatorial Newtonians

A 10-inch is the largest reflector on a conventional equatorial mount that is still reasonably portable. An instrument from this class can show you thousands of deep-sky objects and the clock-driven equatorial mount is a great aid to high-power studies of the planets. Some of the scopes in this class come on heavy-duty mounts — they're rock steady but can push the total telescope weight to over 200 pounds.

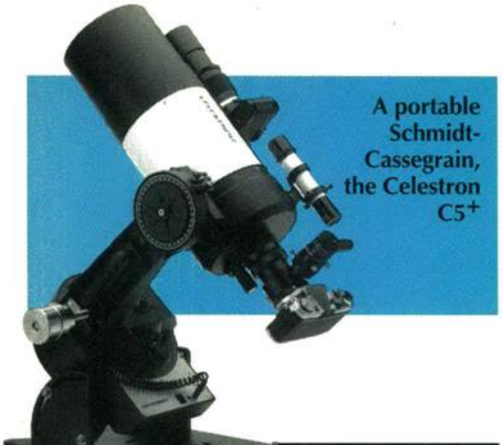
Large Portable Equatorial Newtonians (12-inch and larger)

Jump over 10 inches and most equatorial reflectors become so large and heavy that mounting them permanently in an observatory is the only way to go. (See "Observatory Reflectors" for these models.) However, a few reflectors in the over-10-inch class are designed to be transportable. Some, such as the telescopes from JMI and Jupiter Telescopes, use breakdown truss tubes similar to those found on large Dobsonian reflectors. In this class, the use of ingenious technologies such as low-profile mounts, equatorial tables, or computer-controlled altazimuth drives provides tracking capability without the need for a traditional but heavy German equatorial or fork mount.

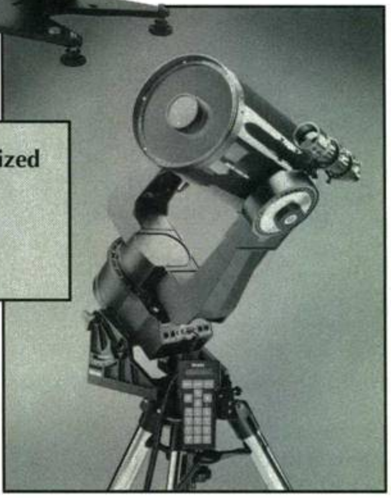
Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Mount design	Drive	Slow motion	Setting circles	Finder	Focuser size (in.)	Average selling price
Small Equatorial Newtonians (3- to 5-inch)											
Edmund	#S31-308	3	6	n/a	Equatorial fork	—	N	N	—	1.25	$219
Meade	#4500	4.5	8	1.13	German equatorial	—	Y	Y	6x30	1.25	$399
Orion	SpaceProbe 4.5	4.5	7.9	1.06	German equatorial	opt.	Y	Y	6x30	1.25	$400
Europtik	CR 4.5 Cosmotron	4.5	7.3	n/a	German equatorial	opt.	Y	Y	6x30	1.25	$450
PI 435	Parallax	4.25	10	0.50	opt.	—	—	—	6x30	1.25	$495
Celestron	C4.5	4.5	7.9	1.06	German equatorial	opt.	Y	Y	5x24	1.25	$530
Swift	#853	4.5	7.9	1.06	German equatorial	opt.	Y	Y	5x24	.965	$550
Bausch&Lomb	Professional	4.5	7.9	1.06	German equatorial	opt.	Y	Y	5x24	.965	$589
Simmons	#6450	4.5	7.2	1.25	German equatorial	—	Y	Y	5x24	.965	$600
Tasco	#302011	4.5	7.9	1.06	German equatorial	opt.	Y	Y	5x24	.965	$688
Takahashi	MT-130ES	5	6.1	2.14	German equatorial	DC	Y	Y	6x30	2.25	$1,925
6-inch Equatorial Newtonians											
Meade	Starfinder 6	6	8	1.18	German equatorial	AC	N	Y	6x30	1.25	$600
Iowa Sc.	NWT-608	6	8	1.25	German equatorial	opt.	opt.	opt.	6x30	1.25	$635
Iowa Sc.	NWT-605	6	5	1.50	German equatorial	opt.	opt.	opt.	6x30	1.25	$645
Parks	6" f/8 Precision	6	8	1.33	German equatorial	opt.	opt.	opt.	6x30	1.25	$800
Parks	6" f/6 Precision	6	6	1.55	German equatorial	opt.	opt.	opt.	6x30	1.25	$800
Iowa Sc.	PNT-612	6	12	0.75	German equatorial	opt.	opt.	opt.	6x30	1.25	$825
Parallax	PI 610 High-Res.	6	8	1.00	opt.	—	—	—	8x50	1.25	$845
Celestron	GP-C6	6	5	2.00	German equatorial	opt.	Y	Y	6x30	1.25	$1,000
Parks	6" f/8 Astrolight	6	8	1.33	German equatorial	opt.	Y	Y	6x30	1.25	$1,000
Parks	6" f/6 Astrolight	6	6	1.55	German equatorial	opt.	Y	Y	6x30	1.25	$1,000
Star Liner	6" Econoline	6	8	n/a	German equatorial	AC	N	Y	6x30	1.25	$1,400
Star Liner	6" Quality	6	8	n/a	German equatorial	AC	Y	Y	6x30	1.25	$2,700
Takahashi	MT-160SE	6.2	6.1	2.48	German equatorial	DC	Y	Y	7x50	2.25	$4,895
Europtik	CR 6 Cosmotron	6	n/a	n/a	German equatorial	opt.	Y	Y	6x30	1.25	n/a
8-inch Equatorial Newtonians											
Meade	Starfinder 8	8	6	1.52	German equatorial	AC	N	Y	6x30	1.25	$700
Iowa Sc.	NWT-806	8	6	1.50	German equatorial	opt.	opt.	opt.	6x30	2	$875
Parallax	PI 810 High-Res.	8	7	1.25	opt.	—	—	—	8x50	2	$1,060
Parks	8" Precision	8	6	1.83	German equatorial	opt.	opt.	opt.	6x30	1.25	$1,200
Star Liner	8" Econoline	8	7	n/a	German equatorial	AC	N	Y	6x30	1.25	$1,590
Parks	8" Superior	8	6	1.83	German equatorial	AC/DC	Y	Y	8x50	2	$2,500
Star Liner	8" Quality	8	7	n/a	German equatorial	AC	Y	Y	6x30	1.25	$3,200
Takahashi	MT-200S	8	6.1	2.48	German equatorial	DC	Y	Y	7x50	2.7	$7,525
Europtik	CR 8 Cosmotron	8	n/a	n/a	German equatorial	opt.	Y	Y	6x30	1.25	n/a
ASKO	SX-210	8.25	6.7	n/a	German equatorial	DC	Y	Y	8x50	2	n/a
10-inch Equatorial Newtonians											
Meade	Starfinder 10	10	4.5	2.37	German equatorial	AC	N	Y	6x30	1.25	$800
Parallax	PI 1010 High-Res.	10	6	1.50	opt.	—	—	—	8x50	2	$1,370
Star Liner	10" Quality	10	6	n/a	Equatorial fork	AC	Y	Y	10x50	2	$2,150
Parks	10" Superior	10	5	2.60	German equatorial	AC/DC	Y	Y	8x50	2	$2,900
Star Liner	10" Quality	10	6	n/a	German equatorial	AC	Y	Y	10x50	1.25	$4,275
Large Portable Equatorial Newtonians (12-inch and larger)											
Parallax	PI 1260 High-Res.	12.5	6	1.83	opt.	—	—	—	8x50	2	$1,890
Jupiter	Juno 12.5	12.5	4.5	2.60	Equatorial table	AC	N	N	Telrad	2	$2,495
Parks	12.5" Superior	12.5	5	3.10	German equatorial	AC/DC	Y	Y	8x50	2	$4,000
JMI	NTT 12	12.5	5	4.00	Computerized altaz	DC	Y	Y	8x50	2	$4,200
Europtik	CR12 Cosmotron	12	n/a	n/a	German equatorial	opt.	Y	Y	6x30	1.25	n/a
Meade	Starfinder 16	16	4.5	4.00	German equatorial	AC	N	Y	8x50	2	$2,195
Jupiter	Juno 15	15	4.5	2.60	Equatorial table	AC	N	N	Telrad	2	$3,495
Jupiter	Juno 18	18	4.5	3.10	Equatorial table	AC	N	N	Telrad	2	$4,795
JMI	NGT 18	18	4.5	4.00	Split-ring equatorial	DC	Y	Y	8x50	2	$10,000
JMI	NTT 25	25	5	9.00	Computerized altaz	DC	Y	Y	11x80	2	$22,500

NOTE: See "Other Reflectors" table for more listings of large-aperture equatorial reflectors.

CATADIOPTRIC TELESCOPES



A portable Schmidt-Cassegrain, the Celestron C5$^+$



A computerized 8-inch SCT, the Meade LX200

Small Schmidt-Cassegrains (3- to 5-inch)

Whether it's to be used as a first scope or as a portable second instrument, a telescope from this class provides a good-sized aperture in an extremely compact package. The optical path of a small Schmidt-Cassegrain folds a relatively long focal length into a tube less than a foot long.

The built-in clock drives in instruments such as the Meade 2045 and Celestron C5 make them suitable for all types of astrophotography. If you are serious about pursuing photography but are on a budget, a 4- or 5-inch Schmidt-Cassegrain is a good way to go. The wide range of accessories available for these models makes it much easier to adapt these scopes to astrophotography than most similarly priced Newtonians or refractors.

PROS...

Versatile for all types of viewing; excellent light-gathering power; compact and portable; closed tube keeps out dust; easy to aim; designed for astrophotography; small models suitable for daytime use.

...and CONS

Occasional collimation adjustments required; large central obstruction causes some loss of contrast; corrector plate attracts dew; more expensive than entry-level Newtonians of similar aperture.

8-inch Schmidt-Cassegrains

This is the class of telescope that for the last 20 years has consistently been the most popular choice among serious backyard astronomers. The big attraction is the portability — the 8-inch Schmidt-Cassegrain telescope, or SCT, provides excellent aperture in a tube only 18 inches long. Many models come with a fork mount with a motor drive built into the base. The fork mount and tube assembly form a unit that stores in a trunk small enough to fit into most cars. A separate tripod and wedge assembly rounds out the package.

Other models use a traditional German equatorial mount. Dual-axis drives are available as either standard or optional equipment.

Convenient to carry to dark sky sites, an 8-inch SCT offers terrific versatility for the visual observer wanting to explore all kinds of celestial targets and for the astrophotographer wanting to capture those objects on film.

The two manufacturers of these instruments, Meade and Celestron, offer a range of models, from basic no-frills instruments to telescopes that can actually aim themselves. The latter use high-speed motors driven by a computer programmed with the locations of hundreds or thousands of deep-sky objects.

The f/10 versions of SCTs are the best all-round choices. Select the faster f/6.3 scopes if deep-sky photography is your passion.

A premium Maksutov-Cassegrain, the Questar 3.5

10- and 11-inch Schmidt-Cassegrains

Both Celestron and Meade offer scaled-up versions of their 8-inch SCTs. Compared to an 8, a 10-inch delivers 55 percent brighter images while an 11-inch offers a gain of 90 percent. You'll certainly see deep-sky objects better through these larger scopes, but be prepared to handle a hefty instrument. As with the 8-inchers, both companies offer both fork- and German-equatorially mounted models in this class.

A new Maksutov-Newtonian, the Ceravolo HD 145

Large Schmidt-Cassegrains (12- to 16-inch)

Though you can move them, Schmidt-Cassegrains as large as these models are best placed in a permanent observatory. Many telescopes in this class offer the same computerized features that have proven so popular in the smaller instruments.

Maksutov Telescopes (3.5- to 9-inch)

Currently enjoying a resurgence in popularity, the Maksutov offers high-quality optics in a compact package. Maksutovs can be expensive per inch of aperture but can provide sharp, high-contrast images. Two variations are available: Maksutov-Cassegrains are relatively long focal length instruments suited to planetary and general purpose viewing. A new crop of premium Maksutov-Newtonians *feature fast f/ratios suited to deep-sky observing,* photography, and CCD imaging, as well as planetary viewing.

Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Mount design	Drive	Speed controls	Finder	Focuser size (in.)	Total weight (lbs.)	Average selling price
Small Schmidt-Cassegrains (3- to 5-inch)											
Meade	#2045D	4	10	1.80	Equatorial fork	DC	N	5x24	1.25	13	$699
Parks	Jovian-4	4	10	1.00	—	—	N	5x24	1.25	4	$1,200
Celestron	C5	5	10	2.00	Equatorial fork	AC	N	5x24	1.25	23	$1,000
Celestron	C5+	5	10	2.00	Equatorial fork	DC	Y	5x24	1.25	23	$1,200
Swift	#854	3.1	12.5	n/a	Equatorial fork	—	N	4x20	1.25	9	n/a
Swift	#856	4.5	8.7	n/a	German equatorial	opt.	N	6x30	.965	21	n/a
8-inch Schmidt-Cassegrains											
Meade	#2080B	8	10	3.00	Equatorial fork	AC	N	6x30	1.25	53	$1,149
Celestron	Classic 8	8	10	2.75	Equatorial fork	AC	N	6x30	1.25	27	$1,250
Celestron	GP-C8	8	10	2.75	German equatorial	opt.	N	6x30	1.25	44	$1,500
Meade	SSC-8	8	10	3.00	German equatorial	DC	Y	8x50	1.25	89	$1,695
Meade	SSC-8	8	6.3	3.45	German equatorial	DC	Y	8x50	1.25	89	$1,695
Celestron	C8+	8	10	2.75	Equatorial fork	DC	Y	6x30	1.25	39	$1,800
Meade	LX100	8	10	3.00	Equatorial fork	DC	Y	6x30	1.25	66	$1,995
Meade	LX100	8	6.3	3.45	Equatorial fork	DC	Y	6x30	1.25	66	$1,995
Celestron	C8+ Computer.	8	10	2.75	Equatorial fork	DC	Y	6x30	1.25	38	$2,250
Meade	LX200	8	10	3.00	Computerized altaz	DC	Y	8x50	1.25	61	$2,295
Meade	LX200	8	6.3	3.45	Computerized altaz	DC	Y	8x50	1.25	61	$2,295
Celestron	Ultima 8-PEC	8	10	2.75	Equatorial fork	DC	Y	8x50	1.25	66	$2,300
10- and 11-inch Schmidt-Cassegrains											
Meade	#2120B	10	10	3.70	Equatorial fork	AC	N	8x50	1.25	76	$1,449
Meade	SSC-10	10	10	3.70	German equatorial	DC	Y	8x50	1.25	116	$1,995
Meade	SSC-10	10	6.3	4.00	German equatorial	DC	Y	8x50	1.25	116	$1,995
Meade	LX200	10	10	3.70	Computerized altaz	DC	Y	8x50	1.25	85	$2,595
Meade	LX200	10	6.3	4.00	Computerized altaz	DC	Y	8x50	1.25	85	$2,595
Meade	LX100	10	10	3.70	Equatorial fork	DC	Y	8x50	1.25	109	$2,695
Meade	LX100	10	6.3	4.00	Equatorial fork	DC	Y	8x50	1.25	109	$2,695
Celestron	Ultima 11-PEC	11	10	4.00	Equatorial fork	DC	Y	8x50	1.25	93	$3,850
Celestron	CG-11	11	10	4.00	German equatorial	DC	Y	8x50	1.25	99	$3,998
Large Schmidt-Cassegrains (12- to 16-inch)											
Meade	SSC-12	12	10	4.00	German equatorial	DC	Y	8x50	2	176	$3,995
Celestron	C14	14	11	4.50	Equatorial fork	AC	Y	8x50	2	171	$7,000
Celestron	Compustar 14	14	11	4.50	Equatorial fork	AC/DC	Y	8x50	2	181	$10,000
Meade	16" LX200	16	10	5.00	Computerized altaz	DC	Y	8x50	2	160	$14,995
Maksutov-Newtonians and Maksutov-Cassegrains (3.5- to 9-inch)											
Cosmos	MC-90 Mak	3.7	5.6	1.20	—	—	—	—	1.25	3	$257
Questar	3.5 Standard	3.5	14.4	1.18	Equatorial fork	AC/DC	opt.	6x	1.25	8	$3,145
Questar	3.5 Duplex	3.5	14.4	1.18	Equatorial fork	AC/DC	opt.	6x	1.25	8	$3,390
ARO	MAK 150	6	10	2.00	opt.	—	—	6x30	2	15	$1,295
Ceravolo	HD 145*	5.7	6	1.00	—	—	—	—	2	12	$1,895
Zeiss	MAK 180/1800	7	10	2.30	opt.	—	—	7.5x42	2	33	$6,000
Questar	Questar 7	7	14.4	2.35	Equatorial fork	AC/DC	opt.	12x	1.25	57	$11,450
JMI	MN-8*	8	3.5	3.10	opt.	—	—	8x50	2	25	$2,495
Ceravolo	HD 216*	8.5	6	1.50	—	—	—	—	2	30	$3,900
Ceravolo	HD 216-PV*	8.5	4	2.60	—	—	—	—	2	30	$4,900
ARO	MAK 230	9	13.5	3.00	opt.	—	—	8x50	2	29	$2,995

* These telescopes are Maksutov-Newtonians; other Maksutovs are Cassegrain designs.

NOTE: All telescopes on this list that include mounts also have slow-motion controls and setting circles.

Telescopes listed in order of increasing aperture. Telescopes of same or similar aperture listed in order of increasing price. Prices are typical selling prices at full-service dealers; prices may vary from dealer to dealer. n/a = data not available; opt. = optional.

A combination Newtonian/Cassegrain reflector, the Parks HIT.

OTHER REFLECTORS

Rich-field Newtonians

A special class of Newtonians, rich-fields use f/4 or faster f/ratios to deliver wide fields for deep-sky viewing and short exposure times for deep-sky photography. Although usable for planetary viewing, these scopes are designed as specialized deep-sky instruments. Models are available from 4-inch all the way up to 16-inch apertures.

Portable Cassegrains (6- to 10-inch)

Unlike Newtonians, Cassegrains use a small secondary mirror to bounce the light back down the tube to an eyepiece at the rear of the telescope. Most Cassegrains are long-focal-length instruments best for planetary viewing. However, both Parks Optical and Star Liner offer telescopes that can be switched back and forth between a fast rich-field Newtonian configuration for deep-sky viewing and a long-focus Cassegrain for planetary viewing, providing high versatility in one instrument.

Observatory Reflectors (12-inches on up)

If you, your club, or your school are setting up a permanent observatory, you may wish to consider a large Newtonian, Cassegrain, or combo Newtonian/Cassegrain as your main instrument. Several suppliers offer telescopes as large as 40 inches. Some scopes are catalog items, many are custom manufactured.

Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Mount design	Drive	Speed controls	Finder	Focuser size (in.)	Total weight (lbs.)	Average selling price
Rich-field Newtonians											
Cosmos	Ultrawide Field	4.25	4	1.52	opt.	—	N	opt.	1.25	6	$347
Parks	Companion	4.5	5	1.33	—	—	N	6x30	1.25	5	$400
Parks	6" Nitelight	6	3.5	1.83	German equatorial	opt.	N	6x30	1.25	55	$1,200
Star Liner	6" Richfield	6	4	n/a	German equatorial	AC	N	6x30	1.25	70	$2,990

Also available: 6", 8", and 10" Ultrawide Field Newtonians from Cosmos; 8", 10", 12.5", and 16" Nitelight Newtonians from Parks; 8", 10", and 12.5" Rich-field Newtonians from Star Liner. Call or write companies for details.

Portable Cassegrains and Newtonian-Cassegrains (6- to 11-inch models)

Parks	HIT Newt./Cass.	6	3.5/12	1.83/2.1	German equatorial	AC/DC	Y	6x30	1.25	70	$2,300
Star Liner	Cassegrain	8	12	n/a	German equatorial	AC	N	6x30	1.25	120	$2,790
Takahashi	Mewlon 180 Cass.	7	12	2.10	German equatorial	DC	Y	7x50	2	68	$3,275
ARO	DK280 Dall-Kirkham	11	12	3.40	opt.	—	N	8x50	2	31	$3,495
Star Liner	Newt./Cass.	8	4/12	n/a	German equatorial	AC	N	6x30	1.25	120	$3,740
O.G.S.	Dall-Kirkham Cass.	7	12	2.10	German equatorial	AC/DC	N	8x50	2	70	$3,995
O.G.S.	Ritchey-Chrétien Cass.	10	8.5	4.60	German equatorial	AC/DC	Y	8x50	2.5	160	$7,350

Also available: 8" and 10" HIT-series Newtonian-Cassegrains from Parks; 10" Classical Cassegrains from Optical Guidance Systems; 10" Cassegrains and Newtonian-Cassegrains from Star Liner; 10" Dall-Kirkham Cassegrain from Takahashi. Call or write companies for details.

Observatory Reflectors (12.5-inch and larger Newtonians and Cassegrains)

Star Liner	Newtonian	12.5	5	n/a	Equatorial fork	AC	N	10x50	2	180	$2,895
Star Liner	Cassegrain	12.5	10	n/a	Equatorial fork	AC	N	10x50	2	190	$3,850
Star Liner	Newt./Cass.	12.5	3.8/11	n/a	Equatorial fork	AC	N	10x50	2	195	$4,250
Parks	HIT Newt./Cass.	12.5	3.5/12	4/4.2	German equatorial	AC/DC	Y	8x50	2	270	$6,600
Parks	Observatory	12.5	5	3.10	German equatorial	AC/DC	Y	8x50	2	515	$11,000
D & G	Classical Cassegrain	20	15	5.00	opt.	—	N	8x50	2.7	90	$11,990
O.G.S.	Ritchey-Chrétien Cass.	12.5	9	5.00	German equatorial	AC	N	8x50	2.5	240	$12,885
Takahashi	Mewlon 300 Cass.	12	7.5	n/a	German equatorial	DC	Y	7x50	3	235	$25,995
DFM	CCT16 Cassegrain	16	12	n/a	Equatorial fork	DC	Y	9x60	—	350	$62,200
ASKO	SE-310 Cassegrain	12.2	15	4.30	German equatorial	DC	Y	8x50	2	1016	n/a
Alaska Appl.	Obs. Newtonian	16	n/a	6.00	Springfield	DC	N	—	3	400	n/a

Also available: 14" to 40" Cassegrains from ASKO; 14.5", 16", and 20" Ritchey-Chrétien Cassegrains from Optical Guidance Systems; 14.5" and 16" Newtonian tube assemblies from Parallax (require user-supplied mounts); 16" Newtonian and HIT-series Newtonian-Cassegrain from Parks; 14.25" to 20" Newtonians, Cassegrains, and Newtonian-Cassegrains from Star Liner. Call or write companies for details.

WOULD YOU LIKE TO LEARN MORE?

For more information about any of the telescopes listed in ASTRONOMY's "1994 Telescope Buyer's Guide," please contact the manufacturer. Most have literature available free or at low cost.

Alaska Applied Sciences, Inc., P.O. Box 020993, Juneau, AK 99802, (907) 586-1426, fax (907) 586-1423.

ARO Instrument Company, 1245 S. 6th Street, Coshocton, OH 43812, (614) 622-8895, fax (614) 622-3231.

ASKO, c/o R.V.R. Optical, P.O. Box 62, Eastchester, NY 10709, (914) 337-4085.

Astro-Physics, 11250 Forest Hills Road, Rockford, IL 61111, (815) 282-1513, fax (815) 282-9847.

Bausch & Lomb Sport Optics Division, 9200 Cody, P.O. Box 14930, Overland Park, KS 66214, (913) 888-0220, fax (913) 888-0222.

Celestron International, 2835 Columbia St., Torrance, CA 90503, (310) 328-9560, fax (310) 212-5835.

Ceravolo Optical Systems, P.O. Box 1427, Ogdensburg, NY 13669, (613) 258-4480, fax (613) 258-3082.

Cheshire Instrument Co., 38 Geraldine Drive, Smyrna, GA 30082, (404) 438-0038.

Cosmos Ltd., 9215 Waukegan Road, Morton Grove, IL 60053, (708) 827-4846, fax (708) 966-2221.

Coulter Optical, P.O. Box K, Idyllwild, CA 92549, (714) 659-4621.

D & G Optical, 6490 Lemon St., East Petersburg, PA 17520, (717) 560-1519.

DFM Engineering, Inc., 1035 Delaware Avenue, Unit D, Longmont, CO 80501, (303) 443-2031, fax (303) 772-9411.

Edmund Scientific, 100 East Gloucester Pike, Barrington, NJ 08007, (609) 547-3488, fax (609) 573-6295.

Fraunhofer Systems Company, 14418 Dickens Street, Suite #6, Sherman Oaks, CA 91423, (818) 986-3601.

Iowa Scientific Optical, 4231 Northwest Drive, Des Moines, IA 50310, (515) 255-0166.

JMI/Jim's Mobile Industries, 810 Quail Street, Unit E, Lakewood, CO 80215, (303) 233-5353.

Jupiter Telescope Company, 810 Saturn Street, Suite 16, Jupiter, FL 33477, (407) 694-1154.

Lorraine Precision Optics, 301 S. Oak Park, Euclid, IL 60302, (708) 383-4197.

MAG1 Instruments, 16342 W. Coachlight Drive, New Berlin, WI 53151, (414) 785-0926.

Meade Instruments Corporation, 16542 Millikan Avenue, Irvine, CA 92714, (714) 756-2291, fax (714) 756-1450.

Obsession Telescopes, 923 Stony Road, Lake Mills, WI 53551, (414) 648-2327 (mornings only), (414) 648-8284.

O.G.S. (Optical Guidance Systems), 2450 Huntingdon Pike, Huntingdon Valley, PA 19006, (215) 947-5571.

Orion Telescope Center, 2450 17th Avenue, P.O. Box 1158, Santa Cruz, CA 95061, (408) 464-0446, fax (408) 464-0466.

Parallax Instruments, 7914 Tifton Road, Charlotte, NC 28226, (704) 542-4817.

Parks Optical, 270 Easy St., Simi Valley, CA 93065, (805) 522-6722.

Photon Instrument, Ltd., 11259 East Via Linda, #100-111, Scottsdale, AZ 85259, (602) 661-1901, fax (602) 661-1901.

Questar Corporation, Route 202, Box 59, New Hope, PA 18938, (215) 862-5277.

Safari Telescopes, 110 Pascask Road, Pearl River, NY 10965, (914) 735-4163.

Simmons Outdoor Corporation, 14530 SW 119 Ave., Miami, FL 33186, (305) 252-0477.

Sky Designs, 4100 Felps, Suite C, Colleyville, TX 76034, (817) 581-9878.

Star-Liner Company, 1106 S. Columbus Blvd., Suite B, Tucson, AZ 85711, (602) 795-3361.

Starsplitter Telescopes, 3228 Rikkard Drive, Thousand Oaks, CA 91362, (805) 493-2489.

Starstorm Optical, 1021 S. Revere, Mesa, AZ 85210, (602) 461-1758.

Sunrise Telescopes, 2470 Stearns Street, Suite 291, Simi Valley, CA 93063, (805) 584-1567.

Swift Instruments, Inc., 952 Dorchester Ave., Boston, MA 02125, (617) 436-2960, fax (617) 436-3232.

Takahashi, c/o Land, Sea, and Sky/Texas Nautical Repair, 3110 S. Shepherd, Houston, TX 77098, (713) 529-3551, fax (713) 529-3108.

Tasco, 7600 MW 26th St., Miami, FL 33122, (305) 591-3670.

Tectron, 2111 Whitfield Park Avenue, Sarasota, FL 34243, (813) 758-9890.

Tele Vue Optics, Inc., 100 Route 59, Suffern, NY 10901, (914) 357-9522.

Torus Optical Works, 67 Bon-Aire, Iowa City, IA 52240, (319) 339-0524.

Unitron, 170 Wilbur Place, P.O. Box 469, Bohemia, NY 11716, (516) 589-6666, fax (516) 589-6975.

Z Optical Shop, 2810 S. Main, Stafford, TX 77477, (713) 499-4993, fax (713) 499-9246.

Zeiss (Carl Zeiss Jena GmbH), Astronomical Instruments Division, Postfach 125, Tatzendpromenade 1A, Jena, Germany, O-6900, (011)-49-3641-588-2557, fax (011)-49-3641-588-2023; in the United States contact Barlow Pepin, General Agent, 783 S. Atmore Circle, Deltona, FL 32725, (904) 789-5007.

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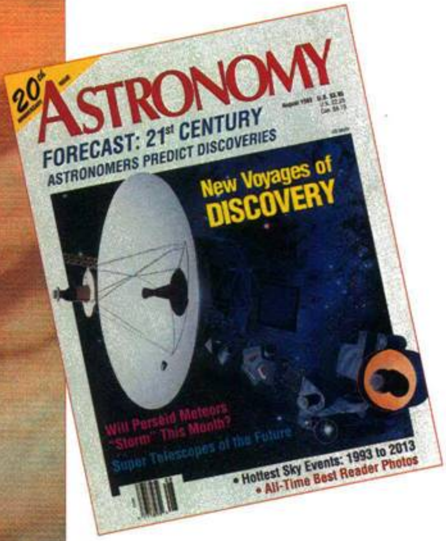
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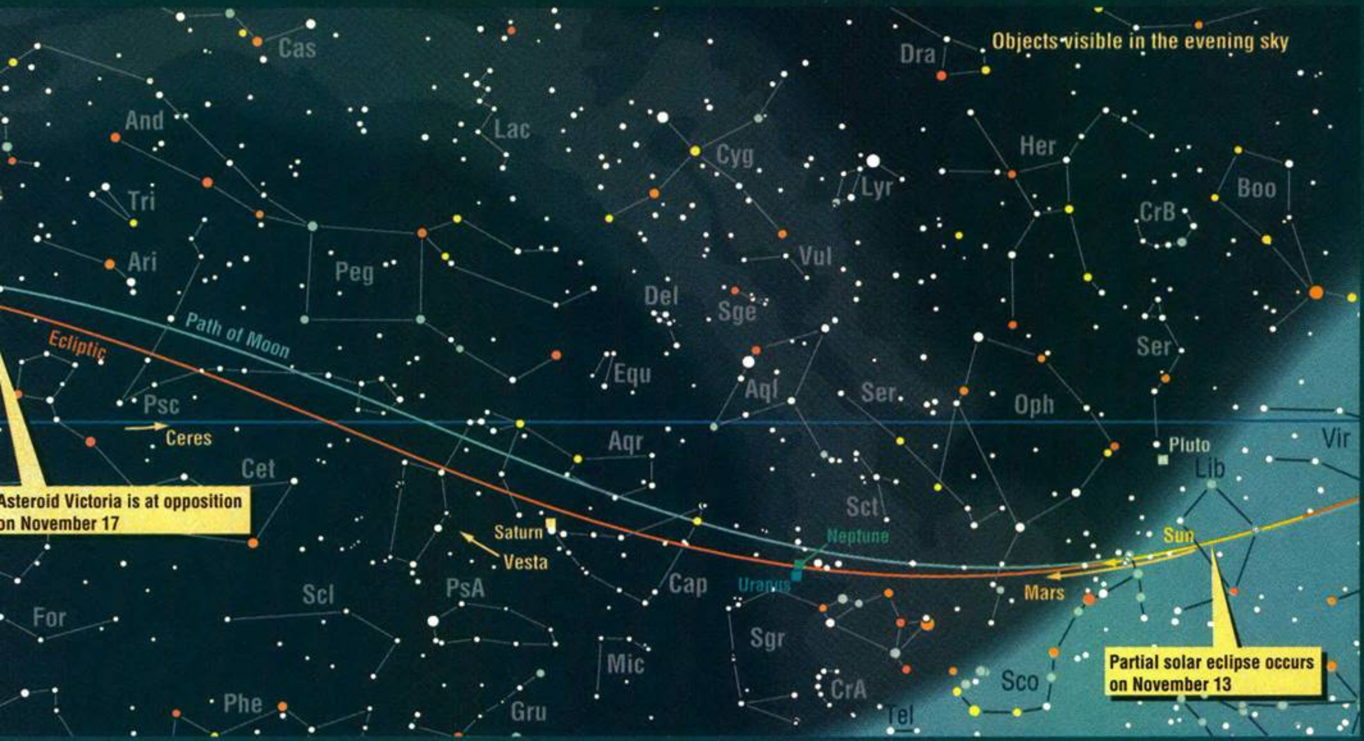
Objects visible in the evening sky
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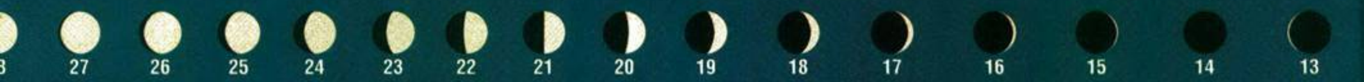
Asteroid Victoria is at opposition
on November 17

Partial solar eclipse occurs
on November 13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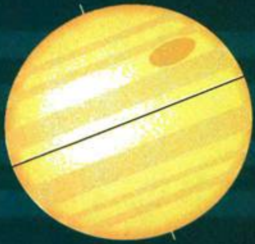
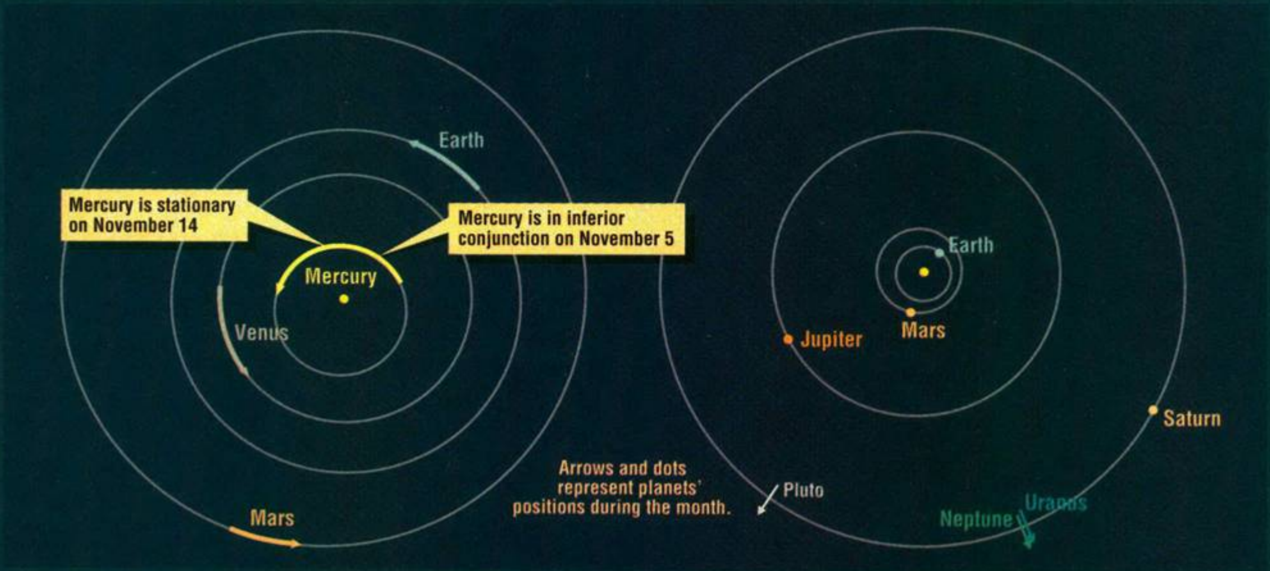


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
November 15	November 15	November 15	November 15	November 15
–1.7	0.7	5.8	8.0	13.8
31.0"	17.1"	3.5"	2.2"	0.1"
100%	100%	100%	100%	100%
6.356	9.718	20.153	30.719	30.718
5.449	9.790	19.625	30.182	29.756
13h56.9m	21h46.8m	19h23.5m	19h21.7m	15h44.9m
–10°49'	–14°57'	–22°31'	–21°29'	–5°46'

The Planets in Their Orbits


Earth
Mercury
Venus
Mars
Earth
Jupiter
Mars
Saturn
Pluto
Neptune
Uranus

Mercury is stationary
on November 14

Mercury is in inferior
conjunction on November 5

Arrows and dots
represent planets'
positions during the month.

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408/255-8770

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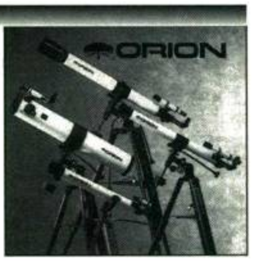
Schmidt-Cassegrains — Celestron pioneered these fantastic instruments, and has an enviable reputation for building unsurpassed, exquisitely fine Schmidt-Cassegrain optical systems.

Refractors — Celestron's high-performance refractors are superb all-purpose telescopes, for astronomical or terrestrial observing. Built to standards that far exceed other telescopes in their class.

Reflectors — Celestron's popular reflector telescopes feature superior optical performance and full-featured, precision equatorial mounts which permit a full complement of optional accessories including electronic drive systems.



TeleVista II 60mm Refractor

Equally at home viewing the rings of Saturn or boats across the bay. Quality 25mm (28x) 1.25"eyepiece, all metal optical tube and yoke mount, finder scope, adjustable tripod, diagonal prism.

#9075 **$239** (8.97)

Sky Explorer II 60mm Refractor

Ideal for lunar and planetary study, plus it's a powerful terrestrial telescope. 900mm f.l, 6x30 finder; star diagonal ; two eyepieces, equatorial mount; setting circles; tripod; and lighted accessory tray.

#9076 **$399** (13.22)

SpaceProbe II 4.5" Reflector

Great 4.5" f/8 reflector, ideal for planetary and deep space. Equatorial mount, slow motion controls, setting circles. 6x30 finder plus 25mm (36x) and 9mm (100x) 1.25" eyepieces. Deluxe tripod.

#9078 **$399** (22.19)

Sky Explorer II 80mm Refractor

Perfect for planetary and lunar observation. Bigger equatorial mount than competitive models, two 1.25" eyepieces, 6x30 finder, star diagonal, deluxe tripod and accessory tray.

#9077 **$577** (32.66)

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#9902 **$399** 8" f/6 — #9904 **$769** 12.5" f/4.8

Prices include precision helical focuser and 25mm Sirius Plossl eyepiece—a $100 value!

These prices are not a misprint! Ideal for both beginners and advanced astronomers, these great new scopes offer high performance and lasting value. Precision 1/8-wave accurate reflector optical systems are ideal for both planetary and deep space observation. Image quality rivals scopes selling for four times their price. Huge light grasp for superb images of faint celestial subjects. See the Great Nebula in Orion in incredible detail. Get lost in the cloud belts of Jupiter. Lunar craters so detailed, you'll think you're in orbit!

Precision Dobsonian-type mounts are the finest in their class. Teflon zero-backlash bearings make it a breeze to track objects without wobble or vibration. Much more stable than comparable equatorial scopes. Lightweight, rugged, easy to transport and set up. Complete instruction manual.

Built to last a lifetime. Primary and secondary mirrors are aluminized and SiO overcoated for durability. Cabinet-quality laminate finish resists dirt and moisture.

Packing & UPS Shipping to any address in the 48 states: 6"—$39, 8"—$49, 10"—$69, 12.5"—$79.

DEEP SPACE EXPLORER

Incredible Value!

Shown with optional finder scopes

The 6" model is the ideal beginner's or family scope - and is incredibly low-priced. Weighing only 29 lbs. complete, it's easily moved or handled by anyone. The 8" model offers 77% more light grasp, but is still a reasonable 39 lbs. and is only slightly larger.

The 10" and 12.5" models are perfect for those who can observe from darker sky locations. While heavier and larger than the smaller models at 68 and 85 lbs., they offer tremendous performance for their low prices.

MONEY BACK
If you are not completely satisfied with your purchase from Orion, for any reason.
100% SATISFACTION
Just return it in new condition within 30 days after delivery for a full refund.
GUARANTEE

Call Toll-Free
800-447-1001

Huge Selection of Astronomy Binoculars

50mm Orion Observer™ II Binoculars — 7x, 10x, & 12x

Fine quality, moderately priced binoculars, excellent for both astronomy and daytime observation. Fully coated optics, unique hand strap for a secure and comfortable grip. Include case and straps.

7x50 #9643 **$89.50** (4.44)
10x50 WA #9644 **$94.50** (4.44)
12x50 WA #9645 **$99.50** (4.44)

50mm Explorer™ Binoculars

High performance large diameter binoculars with BAK-4 prisms and multi-coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design. Include case and straps

7x50 #9306 **$117** (4.44)
10x50 #9308 **$127** (4.44)

New! 10x50 Orion UltraView™

The perfect binocular for eye and sunglass wearers. Extra-long 22mm eye relief and unique rubber pop-down eyepiece guard allows viewing with or without eyeglasses. Fully multi-coated optics provide high light transmission and maximum contrast compared to standard coated types. BAK-4 prisms. Wide 6.5° field of view. Close focus 16'. Weighs 32 oz. Includes case and straps.

#9351 **$159** (4.95)

New! 10x50mm Orion Vista™

Superb for long distance nature observation and astronomy. The image quality will amaze you even when compared to much higher priced binoculars. Fully multi-coated optics provide high-fidelity true color images without ghousting or other aberrations. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. BAK-4 prisms. 5.3° field of view. Weighs just 28 oz. Includes deluxe hard carrying case, rain shield, lens caps, and straps.

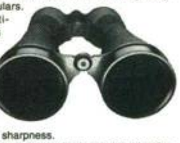
#9353 **$219** (5.19)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501 **Sale! $277** (6.97)
14X70 #9594 **Sale! $288** (6.97)

80mm FMC Giant Binoculars



20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. #9502 **$379** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended. #9496 **$389** (8.05)

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required. #9498 **$399** (8.05)

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7x35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Standard Model #9504 **$159** (4.71)
Rubber Armored Model #9627 **$159** (5.07)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495 **Sale! $777** (29.00)
25x100 #9497 **$899** (29.00)
Shipped by FedEx only.

Observing Aids

NEW! Eyepiece/Accessory Cases

With patented unbreakable latches, die-cut foam inserts.
Inside Dimensions shown
11"x7"x3" #5951 **$17.95** (2.78)
12.5"x9"x5" #5952 **$26.95** (3.36)
16"x11"x5" #5953 **$49.95** (5.19)

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers —fit all Meade & Celestron 8" SCs
DC #3503, AC #3504 **$44.95** (2.98)

10" Dew Zappers—fit all Meade 10" SCs
DC #3506, AC #3508 **$49.95** (2.98)

11" Dew Zappers—fit all Celestron 11" SCs
DC #3510, AC #3512 **$54.95** (2.98)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 **$42.95** (2.98)

Other sizes available for scopes 3.5" to 14"—See our catalog for details

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.

8" Model
#15130 **$33.95** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43)

Now available for Deep Space Explorers!

Ask about other sizes.

Components

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors

Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors

Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis. *See catalog for pricing.*

Finder Scopes New!

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube.

6x30mm — Same unit used on $1000+ "big name" telescopes. With 2-ring bracket, fits scopes 6"-12". #13023 (white) **$44.95** (3.41)

6x30mm Right Angle — 90° prism for right-angle viewing. Includes bracket. #13021 (white) **$59.95** (3.41)

8x50mm—2.7x light grasp of 30mm models. Bright 6.25mm exit pupil. #7090 (white) #7094 (black) **$64.50** (3.41)

8x50mm Illuminated—Wireless illuminator with adjustable brightness. #7092 (white) #7096 (black) **$94.50** (3.41)

9x60mm — 44% more light grasp than 50mm models. #7091 (white) #7095 (black) **$99.50** (3.41)

9x60mm Illuminated—Wireless illuminator with adjustable brightness. #7093 (white) #7097 (black) **$134.50** (3.41)

Mounting Brackets - Unique sliding dovetail design. Super high quality. Fits any scope 6" and over including Celestron & Meade SCs.

8x50mm bracket #5040 **$29.95** (2.98)
9x60mm bracket #5041 **$34.95** (2.98)

Rack-and-Pinion Focusers

Finest in their class. Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.

1.25" #13007 **$49.95** (2.98)

2.0" includes 1.25" adapter. #13003 **$89.95** (3.95)

NEW! Low-Profile Focusers

Perfect for fast optical systems. Ideal replacements for "Odyssey" scopes.

1.25"-#13014 **$39.50** (2.45)
2.0" - #13016 **$59.50** (2.98)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Astronomer's Flashlight #5701	**$9.95** (1.79)
Nitewriter Pen #5709	**$8.95** (1.79)
Hands-Free Flex Light #5707	**$17.95** (2.43)
Starlite LED Flashlight #5714	**$24.95** (2.43)
Celestron LED Flashlight #5720	**$21.95** (2.43)

Observer's Chairs

Standard Model—Adjustable height center column and padded seat. #5935 **$39.95** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty. #5934 **$89.95** (8.02)

Accessories See Our Catalog for Even More!

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.

1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792 **$44.95** (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagon let you view at a right ang from the direction you telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.

1.25" Star Diagonal #8763 **$46.95** (2.98)
.965" Star Diagonal #8761 **$28.95** (2.98)
Hybrid 1.25"/.965" Star Diagonal #14008 **$31.50** (2.98)

2" Prism/Mirror Diagonals

2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771

$199 ea. (4.71)

2" Mirror Diagonal– Affordable, high-quality star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$99.95 ea.** (3.45)

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965" #5268 **$26.95** (2.98)
1.25" #5264 **$28.50** (2.98)
Hybrid 1.25"/.965" #8782 **$28.50** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.

#5262 **$38.50** (2.98)

Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender #5125 **$27.95** (2.98)
Variable Tele-Extender #5127 **$37.95** (2.98)

T-Adapters

Threads to rear cell of telescope, requires t-ring for your camera model.

for SC #5116 **$26.50** (2.98)
for C-90 #7115 **$29.95** (2.98)

T-Rings

Available for many different camera types, call toll-free or see our catalog for your particular model.

Multi-Function Focal Tester

Allows easy, accurate, ultra-sharp focusing, essential for astrophotography.

#7109 **$169** (4.19)

Tripods

Bogen/Velbon/more!
Huge selection of tripods available, for telescopes, spotting scopes and giant binoculars. Choose from assembled models or mix-and-match pan heads and tripods, sold separately. See our catalog for details.

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7012 **$ 44.50** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.

#5014 **$15.95 ea.** (2.43)

StereoScope Viewer

For comfortable two-eyes-open observing. You won't believe the views! Threads securely to the rear cell of your telescope. Requires two identical eyepieces.

#9720 **$479** (5.71)

f/6.3 Reducer/Corrector

Get f/6.3 performance from your f/10 Schmidt-Cassegrain.

#5120 **$169** (3.67)

NEW Model 3 Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few hours!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Complete system requires Sky Wizard Model 1 or 2 and a telescope installation package, sold separately.

Encoders and cables available separately for custom installations. Call for details.

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets.
#7801 **$199** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice.
#7802 **$319** (4.44)

Sky Wizard Model 3
Gigantic 10,000 object database, expanded subject descriptions, RS-232 port.
#7803 **$469** (6.78)

Installation Packages
Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.

Celestron Super Polaris	#27100	**$207** (5.29)
Celestron Ultima 8" & 11"	#27101	**$177** (5.29)
Celestron Great Polaris	#10303	**$314** (5.29)
Celestron C-5	#10304	**$298** (5.29)
Celestron G-11	#10305	**$329** (5.29)
Celestron Classic 8" & Powerstar 8"	#27102	**$177** (5.29)
Meade 8" & 10"	#27103	**$202** (5.29)

Dobsonian (fits Coulter and most others)
Call for stock # for your model **$177** (5.29)

Installation packages available for other telescopes.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.

#5144 **$69.50** (3.45)

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.

#5139 **$119** (4.19)

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.

#17001 **$72.50** (3.95)

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.

#2354 **$109** (8.97)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

NEW! *Solar glass filters for Deep Space Explorer reflectors. Many other sizes available—see our free catalog for details.*

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 **$14.95 ea.** (2.43)

Color Eyepiece Filters

Highest quality precision-ground optical glass. Fully anti-reflective coated. Solar system observations are dramatically improved. Thread into the barrel of any standard eyepiece, or directly into a universal camera adapter.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow #5510 **$46.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$46.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets.
#5517 **$79.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set.
#5575 **$119 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow.
#5513 **$84.95 set** (3.96)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters—Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces. #5660 **$69.95** (3.45)

SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes. #5658 **$89.95** (3.45)

52mm Broadband Filter–For 52mm camera lenses, (Adapter rings available for other diameters.) #5668 **$87.50** (3.45)

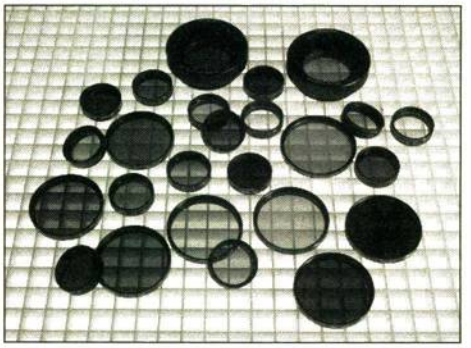
2.0" Broadband Filter–fits 2" eyepieces. #5659 **$109** (3.45)

.965" Broadband Filter–fits .965" eyepieces. #5661 **$49.95** (2.98)

SkyGlow UltraBlock Filters–Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces. #5654 **$87.50** (3.45)

SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes. #5656 **$119** (3.67)



Eyepieces & Barlows

✧ Sirius™ Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for 'famous name' Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!

Sirius Plössls are top-quality, 50° apparent field eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of reflector, refractor and catadioptric telescopes. The Plössl design is renowned for its fantastic performance and has in recent years become the standard by which all other eyepieces are compared.

Each eyepiece is of the classic 4-element Plössl design. Every air-to-glass surface is fully Magnesium Fluoride anti-reflection coated. All lens edges are blackened in the same way as expensive military optics, to further eliminate any scattering of stray light and to maximize contrast.

The optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

We guarantee you'll be impressed with the performance of the Sirius Plössls, even when compared to the more expensive name-brand Plössls.

25mm #8530, *17mm* #8531, *10mm* #8532, *7.5mm* #8533 **$59.95 each** (3.45)

Special Savings-*Buy 2 or more & get case free!*

Any 2	*$54.50 ea.*	*SAVE $23.95*
Any 3	*$48.00 ea.*	*SAVE $48.80*
All 4	*$44.00 ea.*	*SAVE $76.75*

Case only #5911 **$12.95** (2.19)

Explorer .965" & 1.25" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anodized, internally blackened, threaded for filters (except 40mm .965").

.965 Orthoscopic
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583 **$49.50 each** (2.98)

.965 Kellner
18mm #8584, **25mm** #8585
$37.50 each (2.98)

.965 Achromatic Huygenian
40mm #8586
$37.50 (2.98)

1.25" Orthoscopic
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$54.50 each (2.98)

1.25" Kellner
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$39.50 each (2.98)

Superb Ultrascopic™ Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7- element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Guaranteed to beat other brands selling for much more! Unsurpassed high-performance design!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$74.95 ea.** (3.45)

Wide Field 5-element
25mm #8564 **$89.95** (3.45)
30mm #8562 **$94.95** (3.45)
35mm #8560 **$99.95** (3.45)

High Power 7-element *—Long Eye Relief*
5mm #8574, **3.8mm** #8576 **$84.95** (3.45)

MegaVista 1.25" & 2" Eyepieces

These outstanding eyepieces feature a 7-element design and incredibly sharp, fully multi-coated optics. The long eye relief and integral rubber eyeguards make these ideal for eyeglass wearers. The extra wide field of view (67°-70°) provides stunning images, perfect for deep space observing.

10.5mm 1.25" #8552 **$164** (3.67)
16.8mm 1.25" #8554 **$159** (3.67)
34mm 2" #8587 **$209** (3.67)
40mm 2" #8588 **$229** (3.67)

Illuminated Reticle Eyepieces

Orion offers 4 versions of the illuminated reticle eyepiece, a necessity for long exposure astrophotography and very useful for polar alignment. All have 1.25" barrels.

12.5mm Plossl Illuminated Reticle
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$109** (3.45)

12mm Kellner Illuminated Reticle
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$79.95** (3.45)

9mm Orthoscopic Illuminated Reticle
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$109** (3.67)

6mm Orthoscopic Illuminated Reticle
Unique adjustable reticle system. Variable brightness. Needs 2 SR-44 batteries, not included.
#8487 **$129** (3.67)

SR-44 Batteries #2360 **2 for $5.69** (1.79)

UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.

#8556 **$159** (3.67)

See our free catalog for a fantastic selection of name-brand eyepieces!

CELESTRON TeleVue

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$34.95** (2.98)
1.25" #8746 **$44.95** (2.98)
2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.
#8750 **$64.95** (3.45)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$59.95** (3.45)

Shorty Barlows
The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.

.965" #8710 **$46.95** (2.98)
1.25" #8711 **$54.95** (3.45)

Call Toll-Free 800-447-1001

IT'S EASY TO ORDER!

- Call Toll-Free and charge to your MasterCard, Visa or Discover Card or send your personal check to order by mail.
- California residents add 7.25% sales tax (8.25% in Santa Clara and Santa Cruz Counties, 8.5% in San Francisco).
- Shipping & handling charge for UPS Ground or US Mail to lower 48 United States are listed in (parentheses) after each price. We ship to U.S. and Canada only.
- We expected the prices in this ad to be accurate for November 1993 at the time of our advertising deadline in August. Prices are subject to change or correction without notice.

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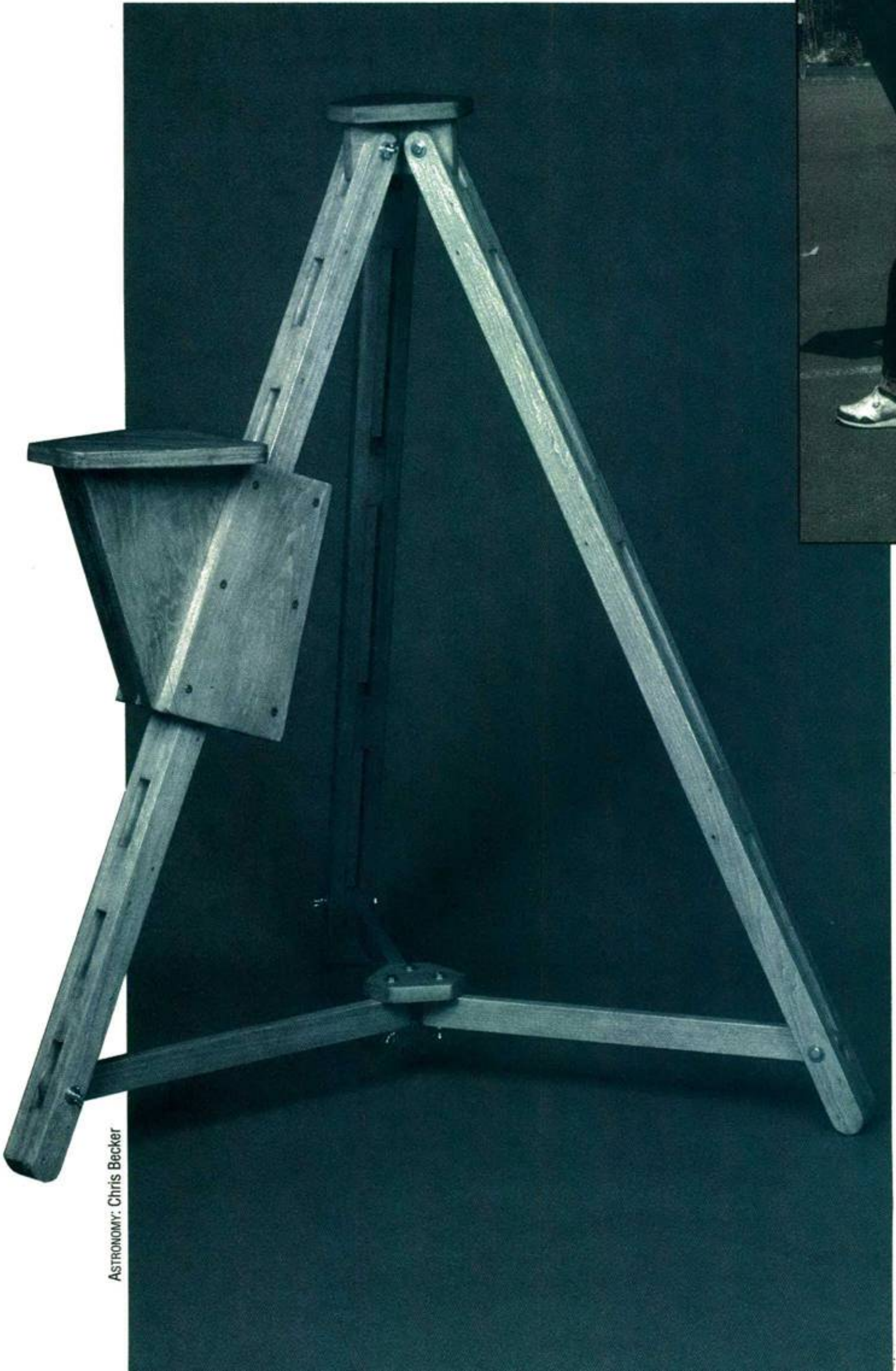
Orion Accessories
#1 for Quality
#1 for Value
Orion accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, and pass along the savings to you! 100% satisfaction guaranteed!

Building an Observing Chair

You no longer need the grace of a ballet dancer to reach your scope's eyepiece. This seat goes up and down to keep you comfortable while you observe.

by Gerald Wolczanski

Gerald Wolczanski



ASTRONOMY: Chris Becker

MATCH YOUR EYEPIECE'S height by adjusting the sliding seat of this observing chair.

A telescope's eyepiece is never at the right height. Either you have to stand precariously on tiptoe or squat indecorously to reach it. A chair can relieve some backache but it's usually too tall or too short. Some commercially available observer's chairs are a little better because they adjust over a range of about six inches in height.

But this range is too small for my Dobsonian. Its eyepiece can vary in height by 30 inches. So I designed my own adjustable chair that uses a tripod base for stability. Its seat slides to a height of 42 inches and down to less than 21 inches. The chair accommodates eyepiece heights of about 40 inches to nearly 70 inches.

You can make a copy of my chair in two or three weekends from five 1x2s eight feet long, a one-foot length of 1x3, a one-foot length of 1x6, a two-foot length of 1x8 or its equivalent in plywood, and a 1' by 3' section of 3/4" exterior-grade (AC) plywood. A one-foot length of oak 1x4 is optional; this piece can be cut instead from 3/4" plywood. Hardware consists of sixteen 3"-long #8 wood screws and nine sets of 3"-long 1/4-20 bolts with washers, lock washers, and wing nuts. The total cost of parts including the finish should run under $50.

Making the Tripod

Each leg of the tripod uses two 1x2s that are 48" long. Eighteen 3"-long 1x2 spacers separate the leg pieces. Two of the legs use four spacers glued and nailed 11" apart. Start with the end of the first spacer flush with the ends of the leg pieces. The third leg uses eight spacers set 3" apart. This leg will hold the seat. Be sure to use a glue rated for exterior use. Finishing nails (3d) hold the spacers in place while the glue sets.

Round the bottom end of each leg so it contacts the ground properly and the top end so it doesn't strike the tripod head when the leg pivots. Drill a 1/4" hole four inches from the bottom of each leg. Drill a second hole in each leg 3/4" from the top end.

The top ends of the legs attach to the tripod head. The head consists of two parts: a horizontal top piece and three vertical leg supports. The top piece should be round or hexagonal to prevent a sharp corner from digging into your back. Cut it from the 1x6.

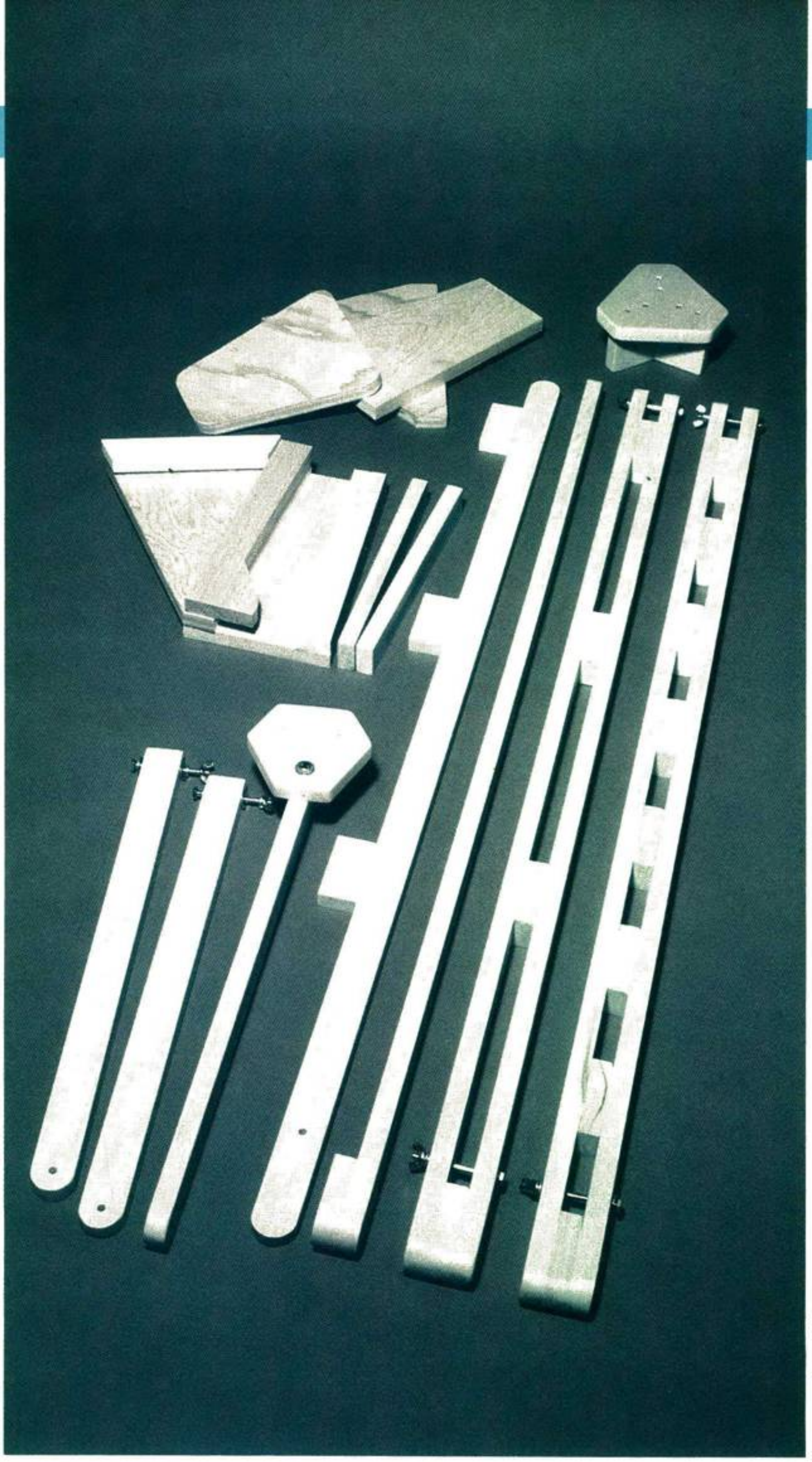
The three leg supports are 2 1/2" lengths of 1x3. Drill a 1/4" hole in the center of each support. For added strength, you can cut one support slightly longer, about 3 1/4". This enables you to bevel the end of the piece, so the support nestles against the ends of the other two.

Set one leg support in place, checking that the wood grain lies parallel with the top piece of the tripod head. Glue and secure this piece in place with two #8 screws. Glue and screw the other two pieces 120° apart from the first piece.

Three spreaders keep the tripod legs from moving apart. These are 20" lengths of 1x2. Round one end and drill a 1/4" hole 3/4" from the end. This end connects to the bottom hole of the leg. Drill a second hole 3/4" from the other end, going through the 1 1/2" dimension of the piece. This end connects to the spreader plate.

The spreader plate can be round or hexagonal, about 4" across. Cut it from the remaining 1x6 material. Drill three holes 120° apart and 1 1/4" from the center. Or you can use two sturdy gate hinges mounted on the sides of the spreaders in place of the plate.

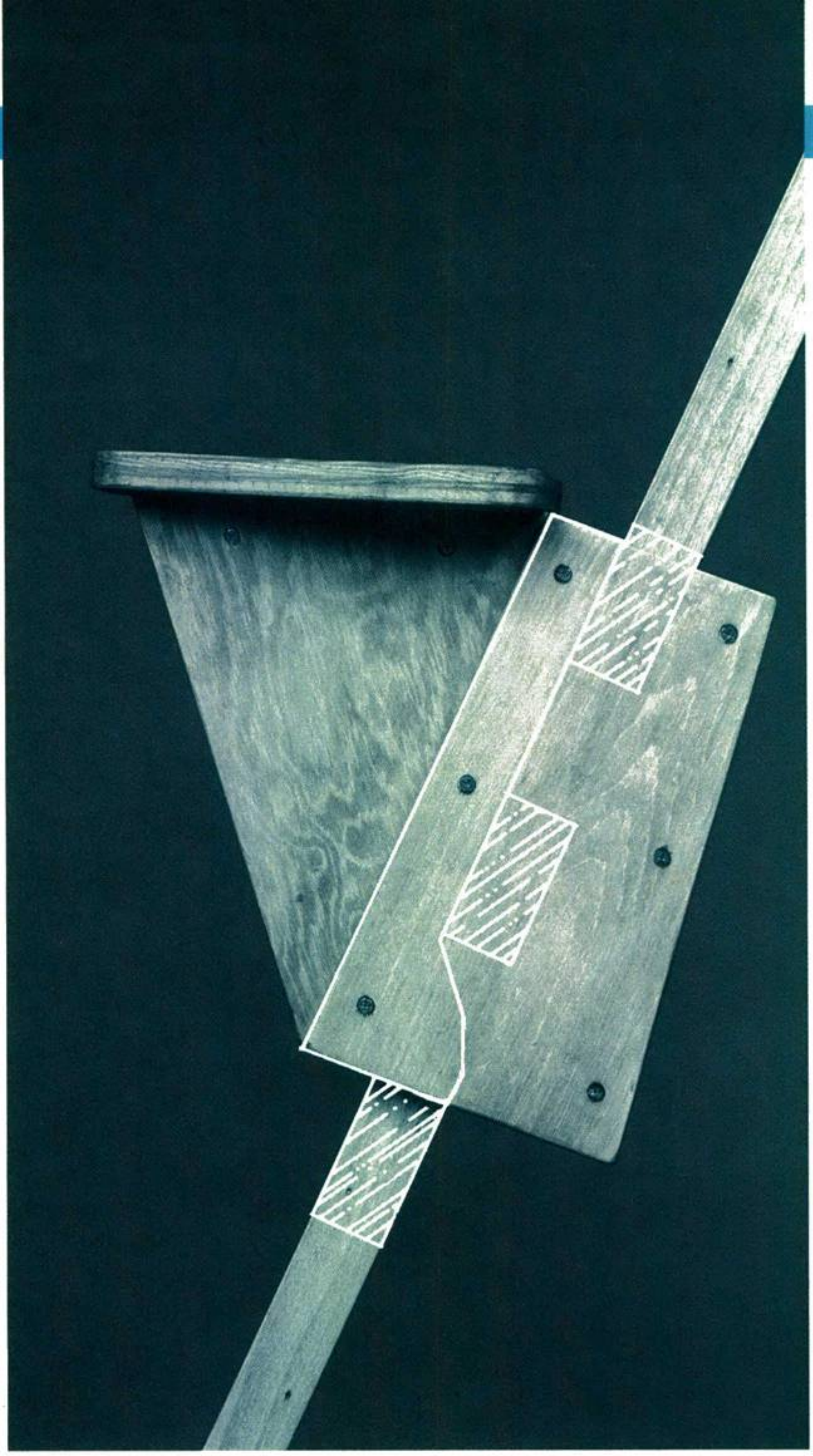
Now is the time to sand and finish the tripod parts. This will help keep the parts from swelling and warping. Use an outdoor enamel or an exterior-grade varnish. Be careful that you don't build up too much paint in the slots of the leg the seat rests on.


ASTRONOMY: James Forbes

FOR LESS THAN $50 you can make the tripod and seat, using readily available lumber and plywood.

The Sliding Seat

The key to the tripod chair is the sliding seat. Hidden in the middle of the seat assembly is a "finger" that engages the slots in the leg. Rocking the seat up disengages the finger



TO ADJUST THE SEAT, simply rock the seat up to disengage the "finger" from the slot in the leg.

ASTRONOMY: Chris Becker and Thomas L. Hunt

and allows you to move the seat up and down.

Start with the sides. Cut these from the 1x8. The bottom of each piece is 6$^1/_2$" across, while the tops are 4$^3/_4$" wide. This trapezoidal shape permits the seat assembly to rock. The back of the seat assembly consists of three 11$^1/_2$" lengths of 1x2.

The front of the assembly is more complicated (see above). It consists of four pieces: two seat supports, the finger, and a seat cleat. Cut the seat supports from $^3/_4$" plywood. Each support is basically triangular with a skinny rectangle added to one of the long sides. The base of the triangle forms the top of the seat support. The long sides of the triangle are 11$^1/_2$", separated by a 21° angle, and the triangle's base is 8$^1/_4$". The "rectangle" replicates a 1x2; it's 1$^1/_2$" wide and 11$^1/_2$" long.

The finger is 11$^1/_2$" long. I made mine from an oak 1x4 since this piece takes the brunt of the weight. The top of the piece is 1$^1/_2$" wide. About three inches from the bottom it starts to flare out, reaching its full 3" width $^3/_4$" to 1" from the bottom.

Sand the bottom "knuckle" part of the finger. This part must slide easily into the slots of the tripod leg, so test fit it in your assembled leg.

Make the seat cleat from an 8$^1/_4$"-long piece of 1x2. Cut the ends so they match the angular sides of the top of the seat support.

To assemble the seat support, glue the three back pieces together and the finger and seat cleat between the two seat supports. Then glue these subassemblies to the side pieces using 2"-long #8 screws to hold the pieces while the glue dries. Drill pilot holes for the screws, especially if you use oak for the finger.

The remaining bit of construction is the seat itself. Use $^3/_4$" plywood for strength. My seat is 9" long, 4" wide at the front, and 7$^1/_2$" wide at the back. Round all the corners and the edges and sand well — you don't want any splinters. Glue and screw the seat to the seat cleat with two screws.

With the seat in place, you can sand and finish the seat assembly. For additional comfort, you can add some foam and cover the seat with vinyl. Or try the gel seat material they sell in bike shops.

Slide the seat assembly onto its tripod leg and then attach the legs to the tripod head with $^1/_4$-20 bolts. Attach the spreaders first to the plate and then to the legs. Now you have a working tripod chair.

To transport your chair, simply remove the bolts holding two of the spreaders to the legs. Rotate the loose spreaders toward the remaining spreader, fold the spreaders up toward the leg, and fold the legs together.

With your new chair, you'll no longer perch precariously over your scope, risking life and optics. And as your eyepiece goes up and down, so will you. ☐

Gerald Wolczanski is an amateur astronomer living in Warrenton, Virginia. You can obtain patterns for the more complex pieces in the tripod chair by sending a self-addressed, stamped envelope to Tripod Chair Patterns, ASTRONOMY Magazine, P.O. Box 1612, Waukesha, WI 53187.

Transform a Bucket into a Dew Cap

Dew is a big problem for Schmidt-Cassegrains. In one evening you can make an inexpensive but effective dew cap from a plastic pail.

by Joseph Kempter

You can spend $40 or $50 for a fancy dew cap for your telescope. Or you can find a plastic bucket at the hardware store for about $5, cut off the top and bottom, and make your own dew cap.

Select a bucket that has the same or a slightly smaller diameter as your scope's tube. Choose one with straight walls, avoiding slick plastic that will make painting difficult. The bucket should have a 10"-deep wall after cutting off the top and bottom. I used a bucket made by Leaktite.

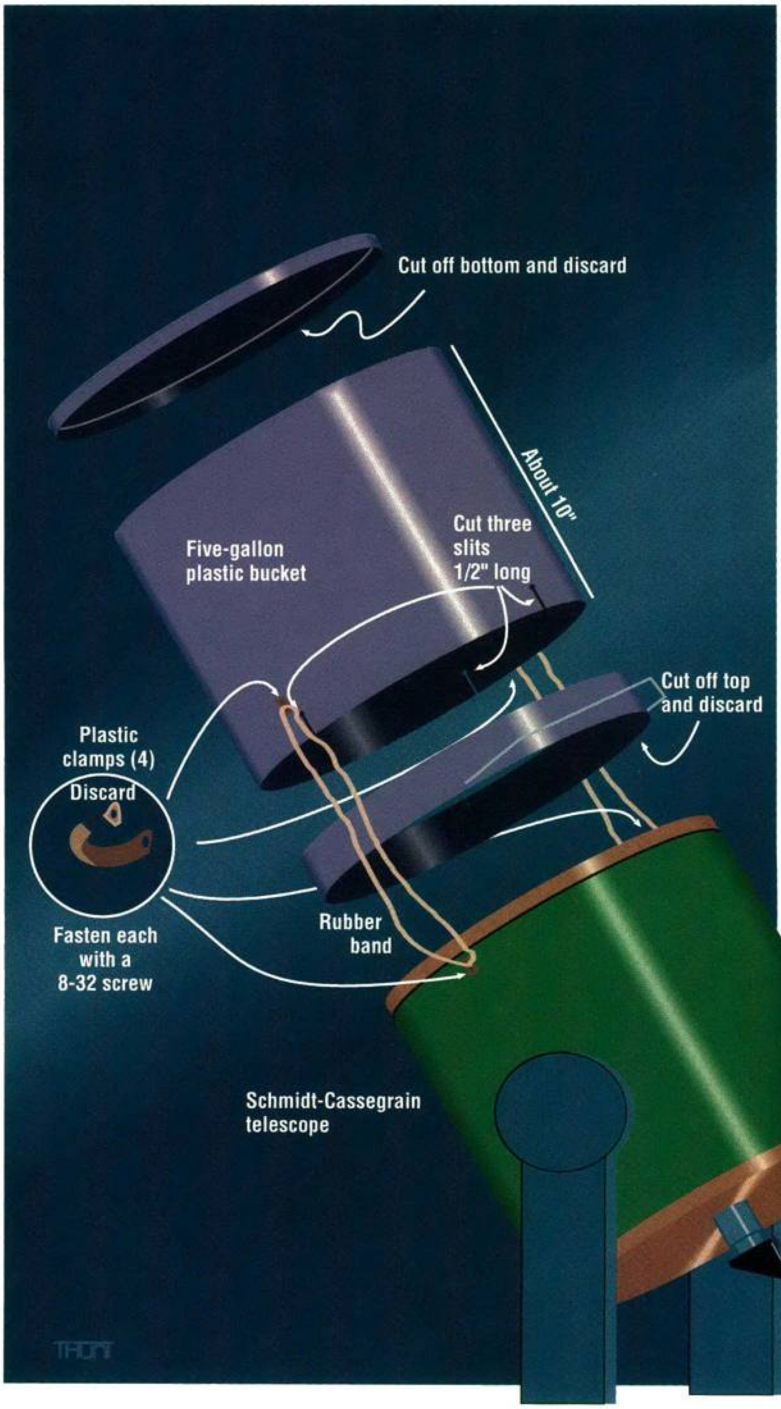
Cut off the bottom, using a sabre saw for rigid plastic and a sharp utility knife for softer plastic. (Watch your fingers!) In cutting the top, remove the handle brackets. Use a strip of thin cardboard wrapped around the bucket as a cutting guide.

You may wish to cut three or four slots about 1/2" deep around the edge of the dew cap that will rest against the telescope tube, especially if the dew cap diameter is the same as the telescope's. A 1/16"-diameter hole at the end of each slot will keep it from enlarging.

Four plastic hooks hold the dew cap to the scope. (Find them in the electrical section of the hardware store.) Two of the hooks go on the scopes; use existing screws on opposite sides of the tube to hold them. Align the remaining two hooks on the dew cap with the scope's hooks and secure them using nylon 8-32 screws and nuts. The plastic screws will prevent damage to your scope's optics should the screws come loose. Rubber bands between the hooks hold the dew cap in place while you observe.

Paint the dew cap flat black with an exterior-grade paint so it won't reflect light. A light sanding before the first coat will help the paint adhere better. Allow at least 24 hours for the final coat to dry. Then your dew cap will be ready to shield your scope from pesky dew. ☐

Joseph Kempter lives in Milwaukee, Wisconsin, where he is no longer plagued by dew.



Cut off bottom and discard
About 10"
Five-gallon plastic bucket
Cut three slits 1/2" long
Cut off top and discard
Plastic clamps (4)
Discard
Fasten each with a 8-32 screw
Rubber band
Schmidt-Cassegrain telescope
THOM

ASTRONOMY: Thomas L. Hunt

ECLIPSE OVER AMERICA

On the night of November 28/29, the skies above North America play host to a spectacular total eclipse of the Moon.

by Alan Dyer and Richard Talcott

A copper-colored Moon stands high in the nighttime sky, lending a warm, soft glow to the chilly autumn landscape below. Such will be the scene on November 28/29 when the Full Moon traverses Earth's shadow. Barring cloudy weather, observers throughout all of North America and most of South America will behold a total lunar eclipse, including all of the partial phases before and after totality. People in western Europe, western Africa, and eastern Brazil fare only slightly worse, seeing some or all of totality before the Moon sets.

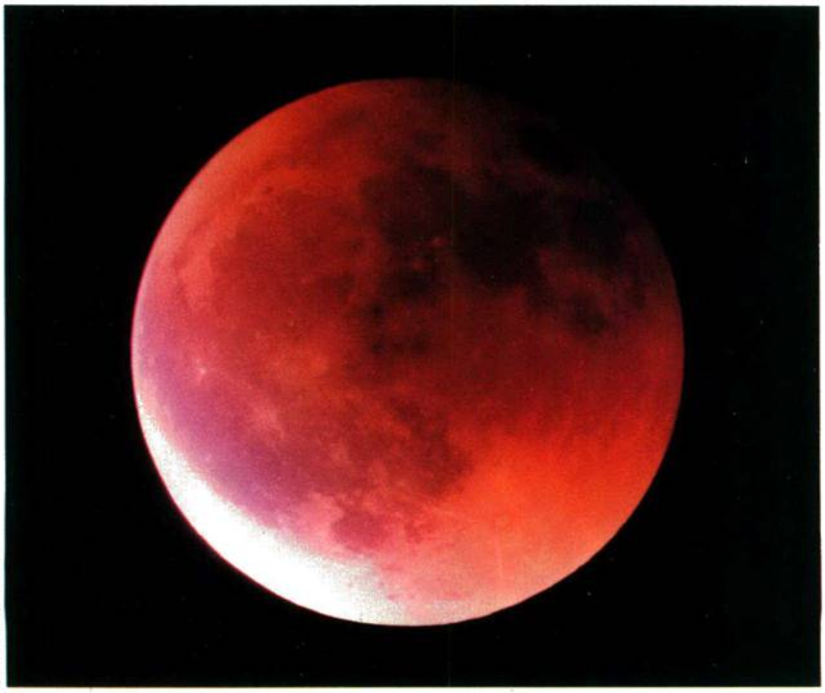
Adding to the drama of this month's eclipse is the Moon's location among the background stars of Taurus. At this time of year Earth's shadow points toward a spot between two famous star clusters — the Pleiades and Hyades. So when the Moon passes through Earth's shadow on November 28/29, the eclipsed Moon lies right between the clusters. Only during eclipses in late November are Earthbound observers treated to such a sight.

Two big unknowns could, quite literally, cloud this picture. The first is whether significant amounts of volcanic debris remain in Earth's atmosphere from the June 1991 eruption of Mount Pinatubo in the Philippines.

SUSPENDED AGAINST THE STARRY BACKGROUND, the totally eclipsed Moon of December 1992 displayed an unusual gradation of color.

Terence Dickinson

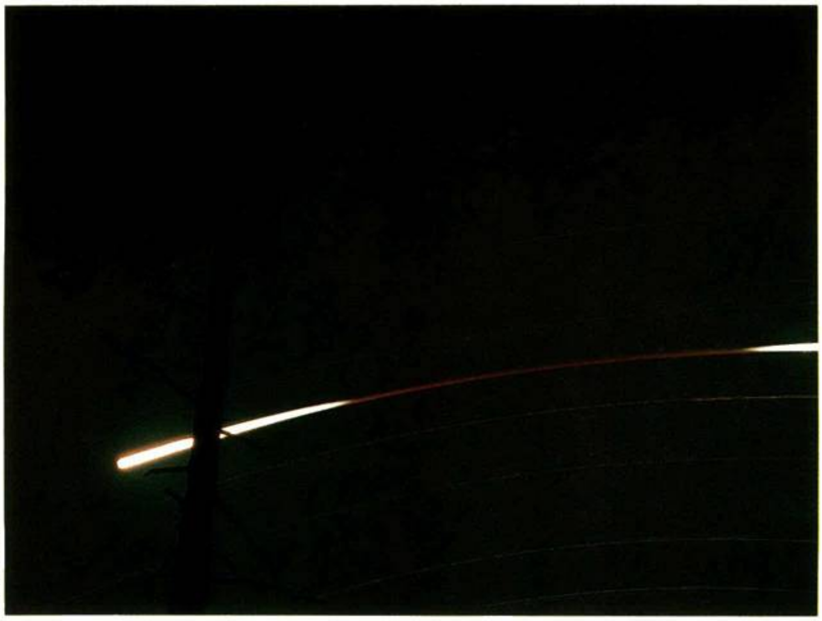
A BRIGHT, COLORFUL ECLIPSE results when Earth's atmosphere is relatively free of volcanic debris, as it was for the April 1986 eclipse (below).



Bill and Sally Fletcher

Henry N. Lore

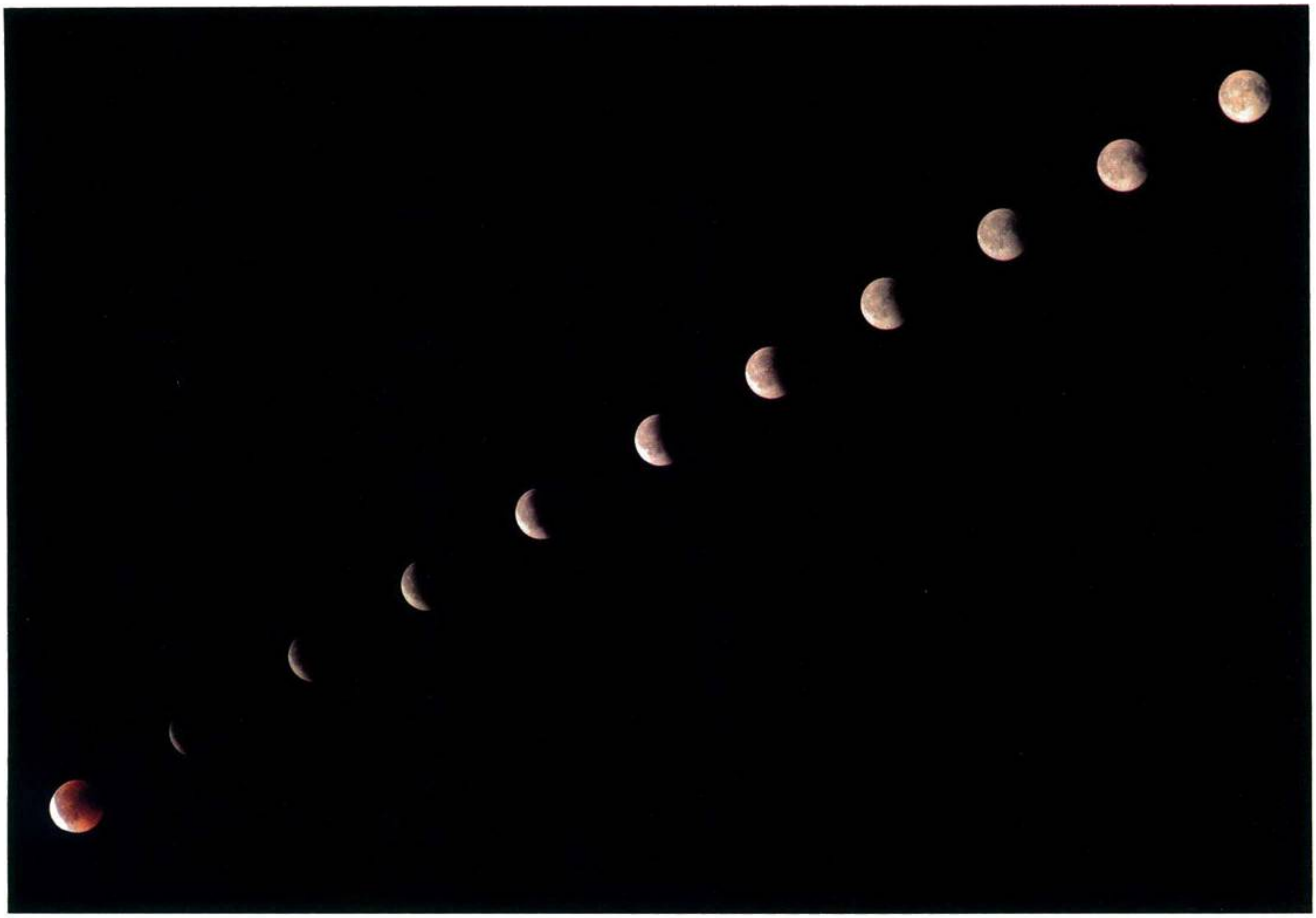
LOOKING LIKE A BLOODSHOT EYEBALL, the eclipsed Moon of August 1989 proved highly photogenic just before totality (above).



Ronald Royer

THE ECLIPSED MOON STREAKS across this long time exposure from July 1982, which captured both partial and total phases of the eclipse on one frame.

This debris could block some of the sunlight passing through Earth's atmosphere on its way to the Moon, causing the eclipse to be darker than normal. The second uncertainty is how clear the sky will be for the eclipse. In some areas of North America at this time of year, cloudy skies are the norm rather than the exception. However even under partly cloudy skies, you should get a reasonably good view of the eclipse.



Bill Sterne

A MULTIPLE EXPOSURE CAPTURES the various stages of the August 1989 total eclipse, from totality at lower left to the subtle penumbral stage at upper right.

Perfect Timing

Observers in North and South America are ideally placed for viewing the eclipse. First contact between the Moon and Earth's penumbra — the light, outer part of the shadow — comes at 10:27 p.m. EST (7:27 p.m. PST) on November 28. That's well after the Moon rises between 4 p.m. and 5 p.m. local time, so the Moon will be well up in the sky, even from the West Coast. Don't expect to see the Moon darken immediately, however — the penumbra imparts only a subtle, nearly imperceptible, shading to the otherwise Full Moon.

You won't see much change in the Moon's appearance until the Moon enters the dark, inner part of Earth's shadow known as the umbra. That occurs at 11:40 p.m. EST (8:40 p.m. PST) and marks the beginning of the partial phase of the eclipse. Within minutes you'll notice a small bite taken out of the Moon's western limb.

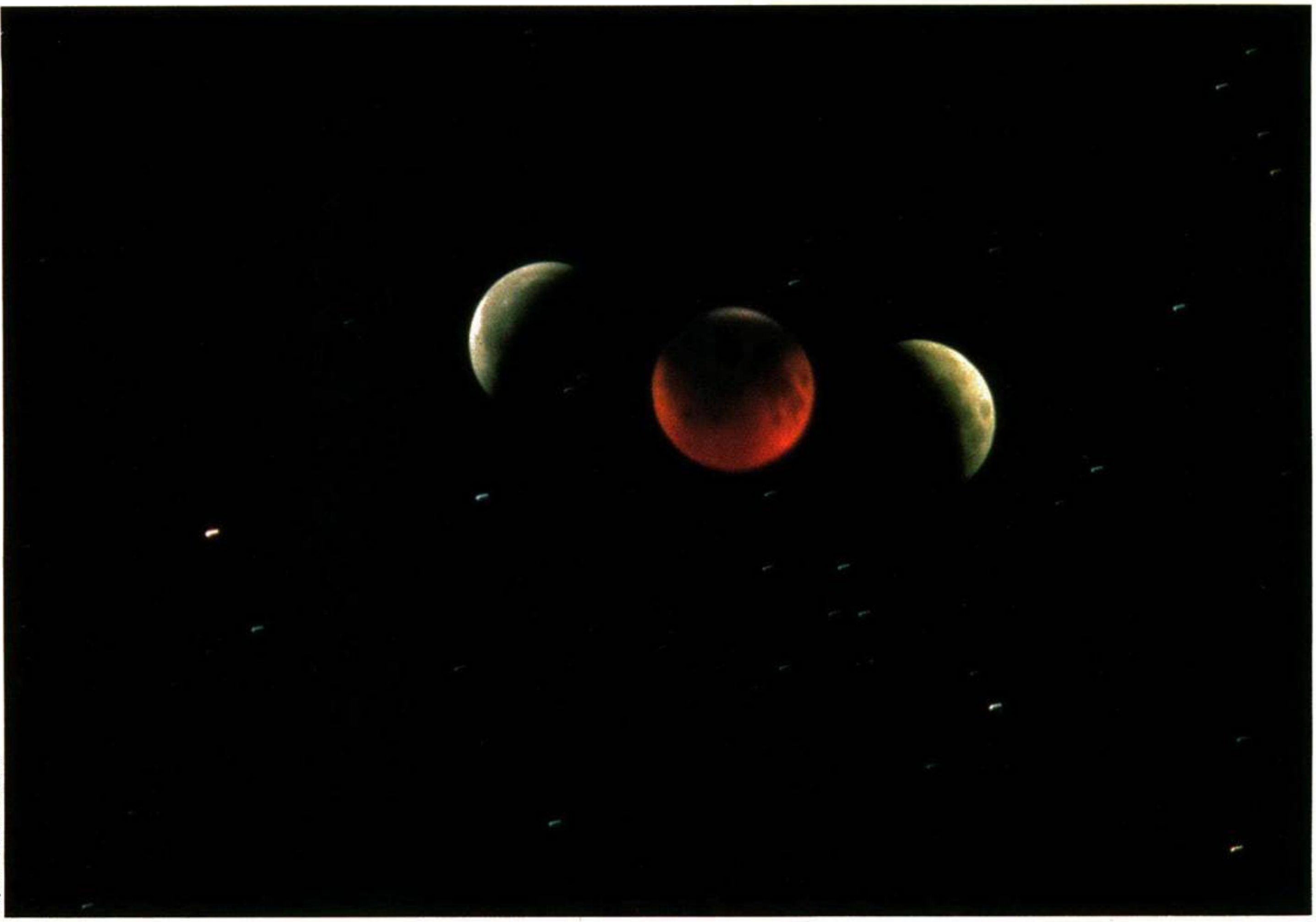
For the next 82 minutes, Earth's shadow inexorably devours the Moon. Finally, at 1:02 a.m. EST (10:02 p.m. PST), totality begins. The Moon remains completely inside Earth's umbral shadow for 48 minutes, emerging into direct sunlight again beginning at 1:50 a.m. EST (10:50 p.m. PST). Then the partial phases of the eclipse play out in reverse order as Earth's shadow gradually relinquishes its grip on the Moon. The partial eclipse ends at 3:12 a.m. EST (12:12 a.m. PST), while the final penumbral phase concludes at 4:25 a.m. EST (1:25 a.m. PST).

Color Me Red

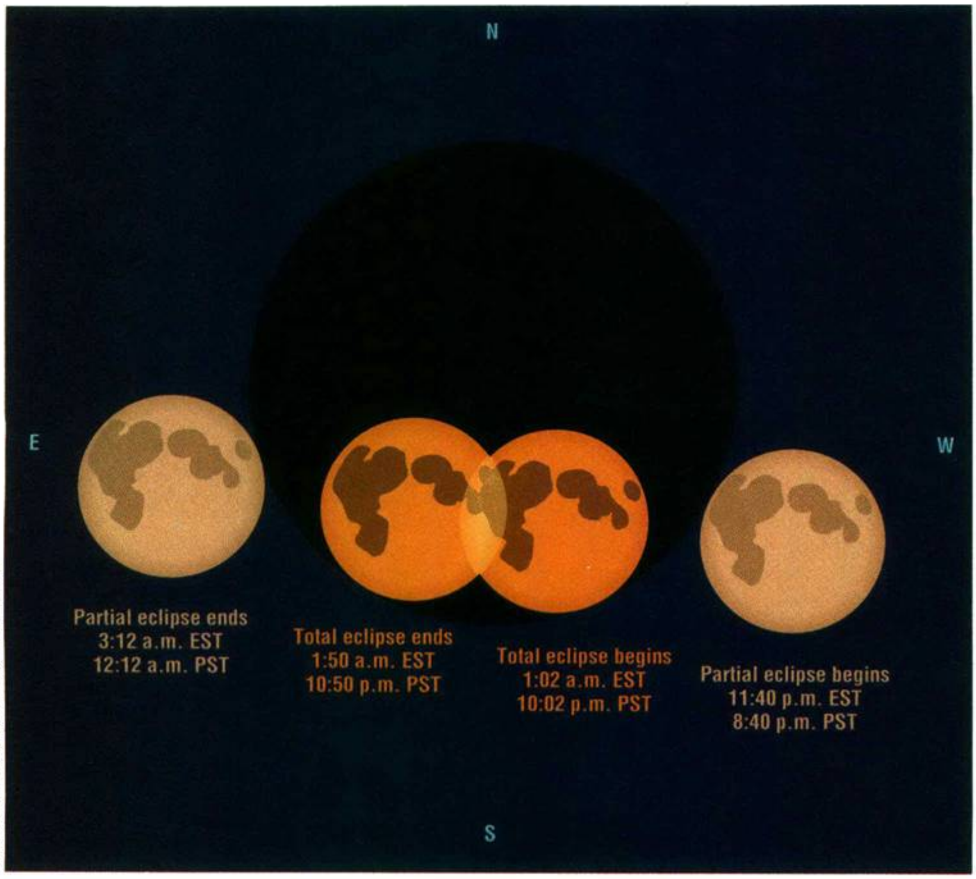
Veteran eclipse watchers enjoy viewing many aspects of a lunar eclipse but none more than the color of the Moon during totality. As sunlight passes through Earth's atmosphere, it is bent and partially fills in the shadow. Red light, by virtue of its longer wavelength, passes through large quantities of air more easily than sunlight of shorter wavelengths, so the Moon takes on a reddish cast as it traverses Earth's shadow. That's also why the sky appears red at sunrise and sunset.

No one knows for sure what color the Moon will display at this eclipse. Debris left from the 1991 eruption of Mount Pinatubo has caused the last few eclipses to appear darker than normal. The eruption injected huge amounts of aerosols and volcanic ash into the stratosphere, blocking much of the sunlight that would normally pass through during an eclipse. But the June 1992 partial eclipse was darker than the December 1992 total eclipse, which in turn was darker than the June 1993 total eclipse. So the thinning of the volcanic debris should make this November's eclipse lighter still.

Another factor working to make this eclipse lighter than the past few is that the Moon will be passing through the southern edge of Earth's shadow. Thus the color will be dominated by sunlight going through the atmosphere above the southern half of the globe. Because Mount Pinatubo lies in the Northern Hemisphere, most of its debris was deposited in the northern half of our atmosphere, where its influence during this eclipse will be significantly less. The best guess is that the Moon will appear significantly redder than during the past few eclipses, though



Benjamin Gomes-Casseres


N
E
W
S
Partial eclipse ends
3:12 a.m. EST
12:12 a.m. PST
Total eclipse ends
1:50 a.m. EST
10:50 p.m. PST
Total eclipse begins
1:02 a.m. EST
10:02 p.m. PST
Partial eclipse begins
11:40 p.m. EST
8:40 p.m. PST

ASTRONOMY: Thomas L. Hunt after Fred Espenak

VOLCANIC DEBRIS FROM MOUNT PINATUBO considerably darkened Earth's shadow, outlined nicely in this multiple exposure of the December 1992 eclipse.

PERFECTLY TIMED FOR NORTH AMERICA, the eclipse of November 28/29 promises spectacular views for those with clear skies.

not as bright red as during the August 1989 eclipse.

Capturing the Scene

If the Moon does appear lighter and redder than in previous eclipses, it will make photographing the eclipse easier and yield more pleasing results. You can get nice results with nothing more than a camera mounted on a tripod. Choose a normal lens (50mm) or a short telephoto and use fast film (ISO 400 to 3200). Set the f/stop to f/2 or f/2.8 and expose for between five and 30 seconds. (Use the longer exposures if you have slower film or if you want to capture more of the starry background.) In any case, keeping your exposures to no more than 30 seconds will keep the background stars from trailing noticeably.

Mark Payne-Gill

A RUDDY LUNAR LANDSCAPE greeted observers of the August 1989 eclipse of the Moon, the last total eclipse visible throughout the Americas.

If your camera allows long time exposures or multiple exposures, you can capture the entire eclipse on a single frame. One technique is to use a wide-angle lens set to f/22 or slower and ISO 64 film. Place the Moon on the left side of the frame at the start of the partial phase, open the shutter, and let the sky's motion streak the Moon across the frame.

The second technique also calls for a wide-angle lens, but this time set it at f/8 and use ISO 400 film. Again start with the Moon at the left of the frame, but this time snap an exposure every five to 10 minutes. For the first half of the partial phase, try exposures of $^{1}/_{125}$ second and then gradually lengthen the exposures until you reach two seconds at the start of totality. During totality you can lengthen the exposures up to 20 seconds, though if the Moon is dark you'll want to change the f/stop to f/4 or f/2.8. Then repeat the process in reverse for the concluding partial phases.

Perhaps the most stunning photos of this eclipse will be piggyback photos showing the eclipsed Moon between the Pleiades and Hyades. For this you'll need an equatorially mounted telescope equipped with a clock drive. Mount your camera on the side of the tube and use the scope as a guiding platform. Choose ISO 200 to 400 film and exposures of two to 10 minutes at f/2.8. An 85mm lens should frame the scene perfectly.

The most challenging photos are those taken through a telescope. You'll need an equatorial mount that has been polar aligned and a clock drive. (If you have an adjustable clock rate, set it to track at the lunar and not sidereal rate.) If this is a bright eclipse, try ISO 400 film and exposures from four to 60 seconds with an f/6 scope. If the eclipse is significantly darker, you'll have to switch to a coarser-grained film (ISO 1600 to 3200) and try exposures of 30 to 90 seconds for an f/6 scope.

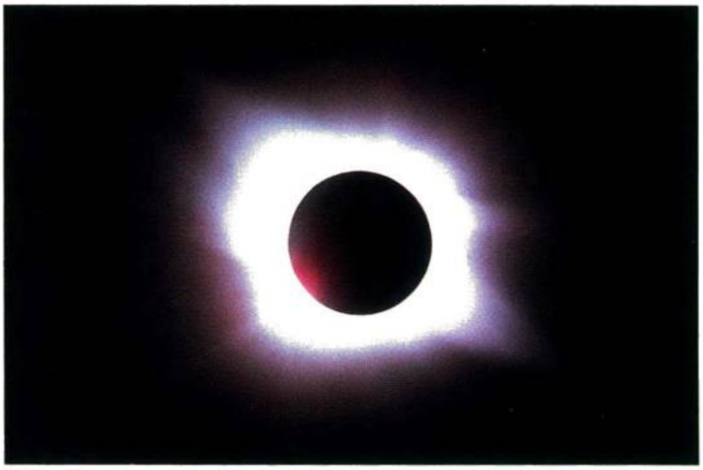
Whatever method you choose, lunar eclipses proceed slowly enough that you have time to try several different films, exposures, and techniques, hoping for that one "killer" shot you'll always treasure.

But don't feel you have to record the eclipse on film to enjoy it. Most people will relish the eclipse immensely if they use nothing more than their naked eye. Binoculars and telescopes enhance the detail you'll see, but they won't let you take in the whole scene as your eyes will. So sit back, relax, and drink in the view — you won't have another chance to see a total lunar eclipse until April 1996. ☐

RETURN TO DARKNESS

The excitement is building. Astronomers are scanning maps of South America. Travel agents are booking tours. It must be time for the next total eclipse of the Sun.

by Jay Anderson and Ken Willcox



Jason Paschal

It's one year and counting. One year until the next total solar eclipse. The immensely popular eclipse of July 1991 across Hawaii and Mexico converted thousands of skywatchers into avid eclipse chasers. If you're an eclipse junkie, your next chance to stand in the Moon's umbral shadow will come November 3, 1994. It's just one year away, not too soon to select your destination and book your trip. The question is, Where's the best place to go?

Next year's show takes place in South America where the Moon's shadow crosses the midriff of the continent from Peru to Brazil, touching Chile, Bolivia, Paraguay, and Argentina along the way. Compared to 1991's spectacle, next year's is not a long eclipse, but with totality lasting between three and four minutes, it's not a short one either. Beyond the eclipse itself, another attraction is that many sites along the path offer excellent weather prospects amid spectacular scenery.

Peru and Chile — Land of the Incas

The Moon's shadow first plants a morning kiss on Earth over the Pacific about 1,500 kilometers west of the South American continent. The shadow touches land on the beaches of Peru south of the capital, Lima. It's an area of dry winds, sand, and gravel terrain. The Pan American Highway runs along the coast, intercepting the northern limit of the shadow path 450 km south of Lima at Nazca. Here, at the start of the eclipse on land the Sun will disappear over the famous Nazca lines, huge ancient geometric patterns of birds, monkeys, and lizards drawn in the desert.

THE PATH OF THE 1994 TOTAL ECLIPSE crosses the middle of South America. This image from the Galileo space probe from December 1992 shows typical weather patterns expected at eclipse time next year: Low clouds hugging the west coast, clear skies over the Andes and Bolivian altiplano, and increasing chances of cloud cover east over Paraguay and Brazil.

NASA/Alfred McEwen and USGS

The center line of the eclipse track runs parallel to the coastline and Pan American Highway for 200 km, finally turning inland at Mollendo, Peru. At this point totality lasts just under three minutes, with the Sun about one-third of the way up in the sky in the early morning.

Mollendo, a port and beach resort of 15,000, promises to be a popular destination for chasers coming from Peru's second-largest city, Arequipa. Accommodations are inexpensive for the adventurous traveler but persistent cloudiness in Mollendo makes it a risky site for eclipse watching.

Most groups heading into this area will bed down at Arequipa, a city of nearly a million people about 110 km to the northeast. Arequipa is on the northern edge of the eclipse path, high on the slopes of the Andes 2,300 meters above sea level and surrounded by spectacular mountains that reach to over 6,000 meters. It's also a region of blue skies and generous sunny days that promise fine weather on eclipse morning.

You can see a total eclipse at Arequipa, but totality will last only 49 seconds. To see the full three minutes you'll need to be near the centerline. To reach the centerline near Mollendo or farther southeast at Moquegua early on eclipse morning you'll need to drive down the slopes of the Andes in the dark. The mountain road is a good one but plan on leaving early to give yourself lots of time to set up before first contact at 6:15 a.m.

Although the Atacama Desert of southern Peru and northern Chile is one of the driest places in the world, weather along the coast in this area is dominated by one unwelcome element — clouds. Just as in Southern California, prevailing winds regularly blow sheets of cloud in from the ocean to cover the coast. It doesn't rain much, but clear skies are found on less than one morning in three.

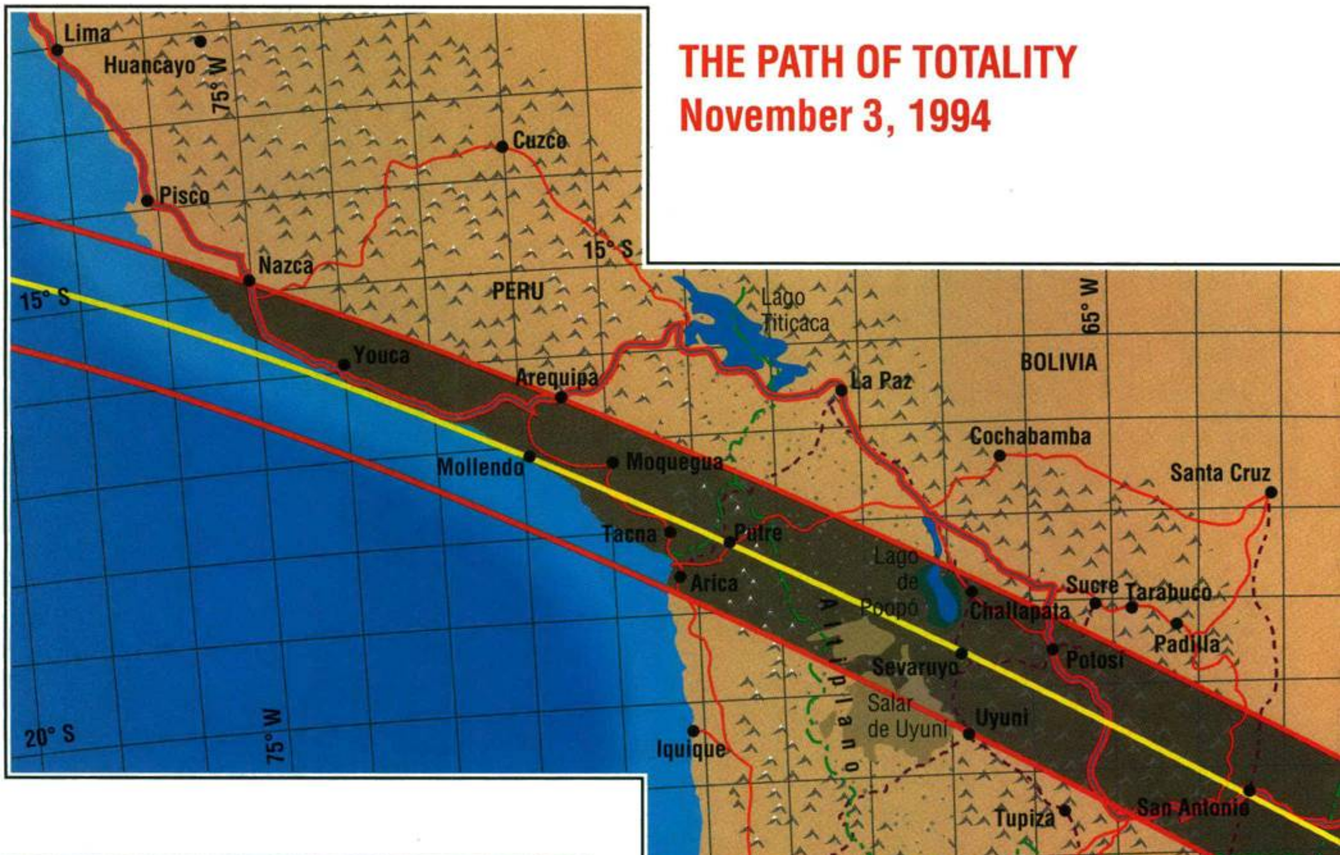
The secret to good eclipse weather in southern Peru and northern Chile is to go inland and uphill. The coastal clouds are not very thick, topping out at about 900 meters. Eclipse sites above the clouds should be easy to find on the steeply rising slopes of the Andes.

Chasers in this area should retreat uphill if clouds threaten. For example, if you're coming toward Mollendo from Arequipa, don't go beyond Guerreros Estaçion unless you can see that the lower slopes are cloud free. Guerreros Estaçion is a small railway stop about 15 km from the centerline and 1,100 meters above the sea. But be careful — clouds can move upslope very rapidly in the strong sea breezes and falling temperatures after first contact can bring a quick return to gray skies.

Just how good is the weather on the higher slopes? Statistics at Arequipa show that two mornings out of three are sunny in November, monthly rainfall is very low (and usually comes in the afternoon), and fog is almost unknown. These statistics probably hold good for any Peruvian

(continued on page 92)

THE PATH OF TOTALITY
November 3, 1994


Lima
Huancayo
75° W
Cuzco
Pisco
15° S
Nazca
PERU
Lago Titicaca
65° W
15° S
Youca
BOLIVIA
Arequipa
La Paz
Cochabamba
Mollendo
Moquegua
Santa Cruz
Tacna
Putre
Lago de Poopó
Arica
Challapata
Sucre
Tarabuco
Padilla
Altiplano
Sevaruyo
Potosí
Salar de Uyuni
Uyuni
20° S
75° W
Iquique
San Antonio
Tupiza
La Quiaca
CHILE
Antofagasta
70° W
Salta
65° W
25° S

Herb Beebe

THE ANDEAN PLATEAU NEAR PUTRE, CHILE, is dotted with snow-capped volcanos and offers good chances for clear skies within a 100-kilometer drive of Arica, a major port and resort town. The altitude near Putre is over 4,000 meters.

Joel Harris

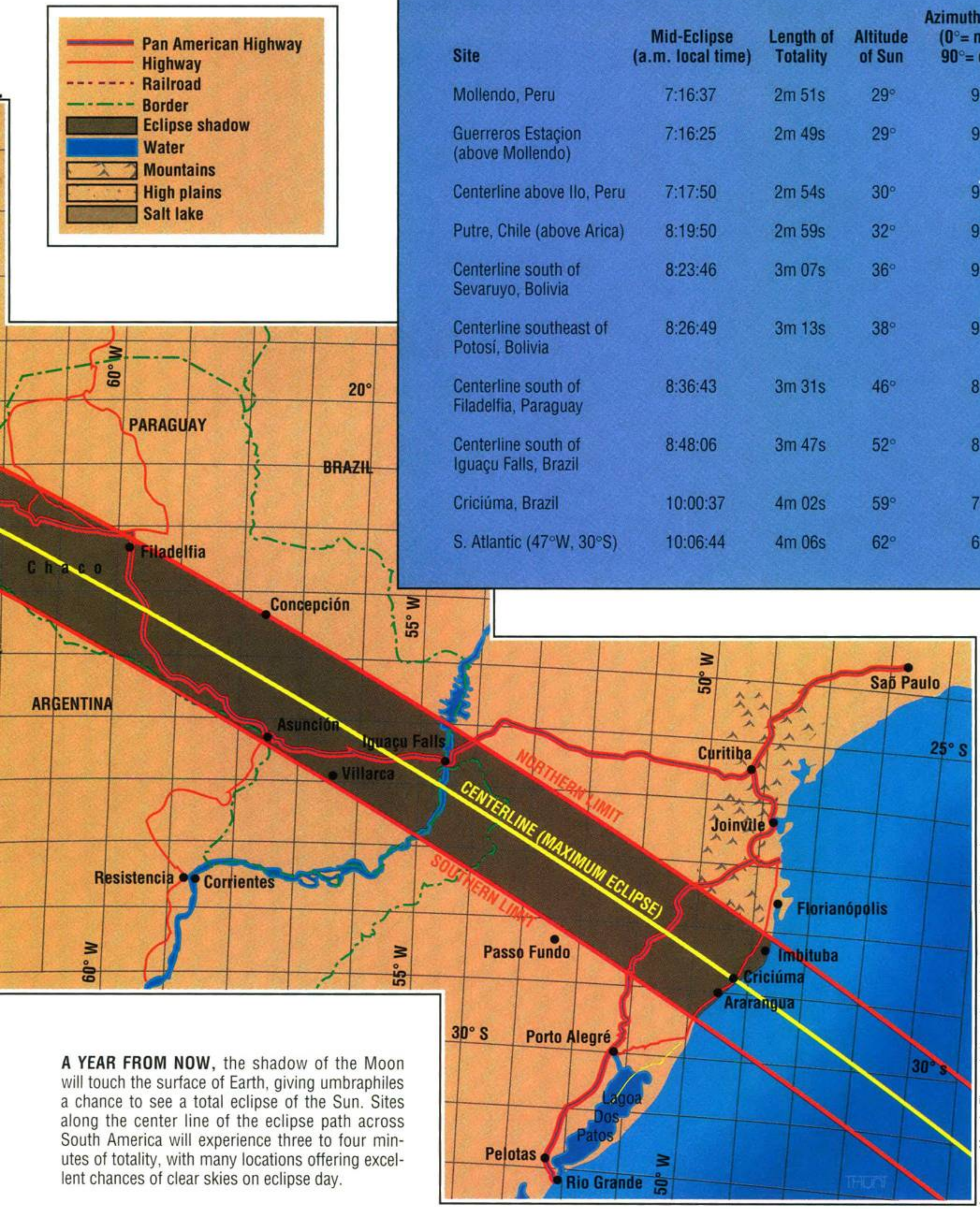
SOUTHEAST OF POTOSÍ, BOLIVIA, the eclipse centerline crosses one of central Bolivia's few highways, a gravel road typical of the area. Driving across the high plains of the altiplano is best done with a four-wheel drive vehicle and an experienced guide.

Ken Willcox

HUNDREDS WILL GATHER HERE next year, on the Bolivian altiplano near Sevaruyo, Bolivia. Taken on the centerline on November 7, 1992, the photo shows high-altitude clouds that sometimes move in from the Pacific.

ECLIPSE TIMES

Site	Mid-Eclipse (a.m. local time)	Length of Totality	Altitude of Sun	Azimuth of Sun (0°= north, 90°= east)
Mollendo, Peru	7:16:37	2m 51s	29°	98°
Guerreros Estaçion (above Mollendo)	7:16:25	2m 49s	29°	98°
Centerline above Ilo, Peru	7:17:50	2m 54s	30°	97°
Putre, Chile (above Arica)	8:19:50	2m 59s	32°	97°
Centerline south of Sevaruyo, Bolivia	8:23:46	3m 07s	36°	95°
Centerline southeast of Potosí, Bolivia	8:26:49	3m 13s	38°	94°
Centerline south of Filadelfia, Paraguay	8:36:43	3m 31s	46°	88°
Centerline south of Iguaçu Falls, Brazil	8:48:06	3m 47s	52°	81°
Criciúma, Brazil	10:00:37	4m 02s	59°	70°
S. Atlantic (47°W, 30°S)	10:06:44	4m 06s	62°	64°


Pan American Highway
Highway
Railroad
Border
Eclipse shadow
Water
Mountains
High plains
Salt lake
60° W
20°
PARAGUAY
BRAZIL
Chaco
Filadelfia
Concepción
55° W
ARGENTINA
Asunción
Iguaçu Falls
Villarca
NORTHERN LIMIT
CENTERLINE (MAXIMUM ECLIPSE)
SOUTHERN LIMIT
Resistencia
Corrientes
60° W
55° W
50° W
São Paulo
25° S
Curitiba
Joinvile
Florianópolis
Passo Fundo
Imbituba
Criciúma
Ararangua
30° S
Porto Alegré
30° S
Lagoa Dos Patos
Pelotas
Rio Grande
50° W
T.HUNT

A YEAR FROM NOW, the shadow of the Moon will touch the surface of Earth, giving umbraphiles a chance to see a total eclipse of the Sun. Sites along the center line of the eclipse path across South America will experience three to four minutes of totality, with many locations offering excellent chances of clear skies on eclipse day.

ASTRONOMY: Maps by Thomas L. Hunt, after Jay Anderson and Fred Espenak site above 1,000 meters along the eclipse track.

By comparison, the area around low-lying Tacna near the Peruvian coast is the cloudiest on the west coast. Satellite pictures show clouds piling up day after day along this part of the coastline, flowing inshore to lap against the mountain slopes.

Much the same can be said for Arica, a coastal city on the Chilean side of the border. Near Arica, the center of the path passes about 10 km northeast of the village of Putre, at an altitude of nearly 4,000 meters. Though the distance upslope to the centerline from Arica is farther than that from Tacna, the area around Putre is virtually on the Andean plateau and should be a good site. Plan to head up the day before, as it's a long 100-km drive from Arica to Putre on a gravel road.

Bolivia — On the Altiplano

Imagine a wide, flat plain as high as the 4,200-meter summit of Mauna Kea, crossed by meandering rivers and surrounded by some of the world's tallest mountains. This is the Bolivian altiplano. Known locally as the Puno, it is one of the great outbacks of the world, homeland of the Incas and studded with mysterious ruins. What a place for an eclipse!

Acclimatization to the altitude of the altiplano is an absolute must. At 4,000 meters the air contains only 60 percent of the oxygen that it does at sea level. Arrive early, allowing yourself several days to adjust to the thin air. And be prepared for cold weather. Although it's late spring, temperatures at night on the altiplano in November can drop to –5° C (23° F).

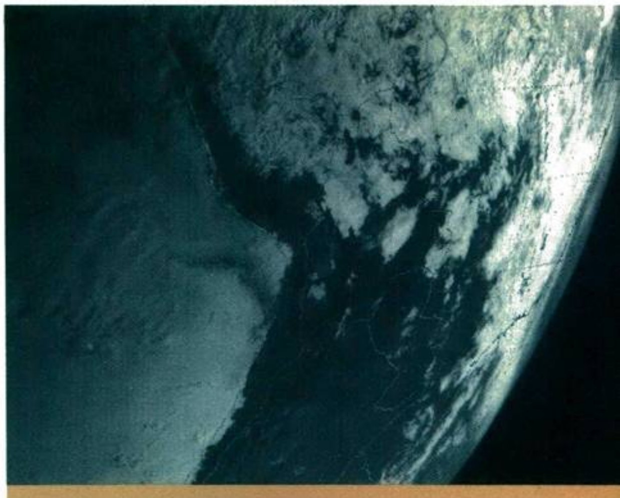
Also be prepared for some adventurous road travel. While the highway south from La Paz, Bolivia, to Oruro is paved and in good condition, the road from Oruro to Challapata, on the east shore of Lago de Poopó and just inside the eclipse path, is dusty and rough. The last gas station going south to the eclipse path is at Oruro, and everything you need must be carried with you.

South of Challapata, only four-wheel drive vehicles and an experienced Bolivian guide can avoid the sand and occasional shallow stream. There are no road signs and travel is done in daylight only. In a scouting trip last November, it took us 10 hours to drive between Potosí, Bolivia, and Challapata. During that time we saw no other vehicle and only one family walking near Río Mulatos.

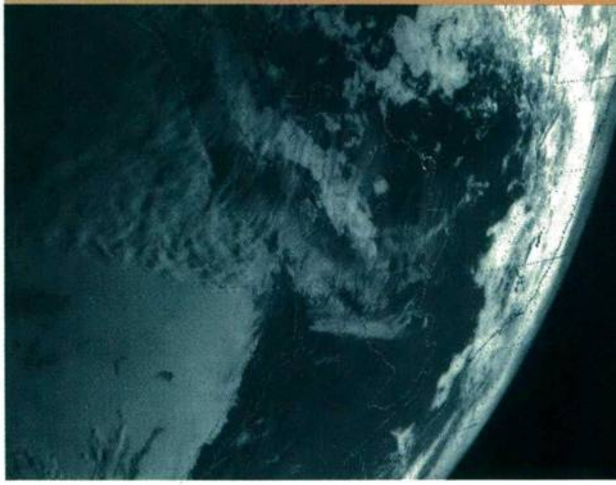
Why travel to an area where facilities are limited, travel difficult, and the air thin enough to make breathing, walking, even thinking difficult? The answer is the skies. The altiplano provides the best chances for clear skies for this eclipse. If corona — endless, arching corona — is what you want to see, then the high-altitude Puno of Bolivia is the place to be. And don't forget the stunning views you'll get at night of the Magellanic Clouds and the stars of the southern hemisphere.

The transparent skies of the altiplano are due to topography. First, its extreme altitude means the amount of water vapor in the atmosphere is much less than at lower altitudes. Second, the fortress of peaks to the east and the west block all but the highest weather systems, wringing moisture from the winds that manage to blow over their summits.

Still, there are clouds here on one day out of three or four, according to the statistics from stations in the area. Weather systems arrive from both the Atlantic and Pacific side, but clouds from the Pacific tend to be more transparent and filamentary than those from the east. Since these tend to be large-scale disturbances, outrunning them could be difficult on the sparse road network of the Puno.



IDEAL ECLIPSE WEATHER over South America appears on the image above taken by the GOES 7 weather satellite on November 6, 1992. Low cloud hugs the west coast but much of the eclipse track is clear. But the next day, below, a high-level disturbance has blown patchy cloud over key eclipse sites. Compiled from images such as these, the chart at right plots the frequency of clear skies or scattered cloudiness at each longitude along the path for October 22 to November 21 in 1991 and 1992. The higher the bar the greater the chance of good skies.

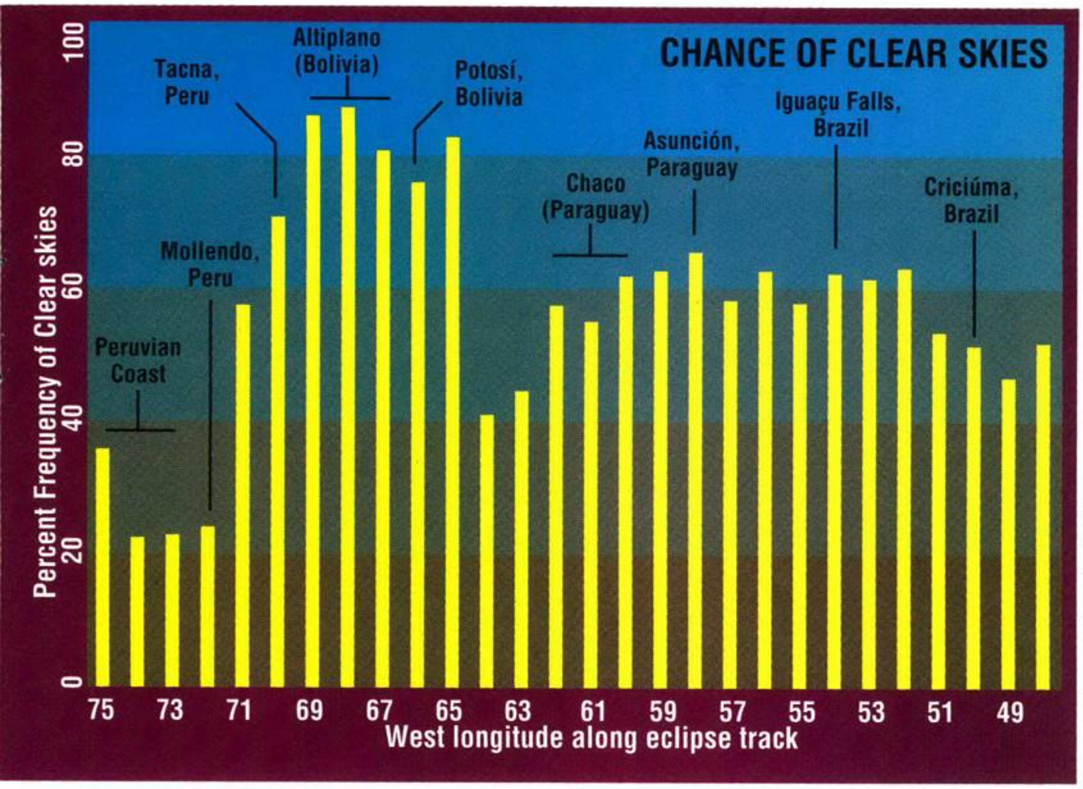


Both photos by Environment Canada

The easiest way to travel on the altiplano is by train, though Bolivian trains are not noted for their punctuality. Tour organizers such as the Astronomical League and Travel Bug International plan to charter trains out of La Paz. The trains will transport eclipse chasers to the center line south of Challapata near Sevaruyo and proceed to a nearby siding to sit out the eclipse. Afterward they will return to gather the crowd, moving on to other destinations or returning to La Paz. Other groups, such as the Amateur Astronomers, Inc. led by Roger Tuthill and Beth Yule, plan to travel to the Sevaruyo area by bus.

Leaving the altiplano, the Moon's shadow passes 4,000-meter-high Potosí, the highest city in the world and descends the eastern slopes of the Andes. The Pan American Highway out of Potosí crosses the centerline about 120 km southeast of the city, and a number of tours from both Europe and North America are planning to assemble here. Satellite pictures from November 1991 and 1992 show that the prospects for clear skies in the area are about 80 percent, nearly as good as on the altiplano.

Joel Harris of Twilight Tours scouted the area last November, visiting the centerline southeast of Potosí. He describes a road with spectacular vistas of deep mountain gorges, opening up into a wider valley with a good eastward view to the Sun at the



ASTRONOMY: Thomas L. Hunt, after Jay Anderson

centerline. It, too, was a winding dusty road but more passable than the track upward to the altiplano west of Potosí.

Because the eastward-facing slopes are exposed to the moist winds of the Atlantic, cloud cover in the area increases rapidly as you head east. Except for the Peruvian coast, sites on the path between longitudes 64° and 63° west are statistically the cloudiest of the whole track. Our advice is to avoid sites along the Bolivia-Paraguay border.

Paraguay — across the Gran Chaco

Leaving Bolivia and the Andes, the Moon's shadow moves onto the dry scrub forests of the Gran Chaco, an extension of the foothill plains of Argentina into western Paraguay. Prospects for clear skies improve again as the track crosses the Chaco of Paraguay. Statistics show that shadow-chasers can expect sunny skies on one-third to one-half of November mornings.

Between Asunción and Concepción the total eclipse will last three-and-a-half minutes, with the Sun now more than half way up in the sky. Travel through the area is easy, with good paved roads leading north, west, and east from Asunción to intercept the centerline.

The two most popular spots, probably for the whole eclipse, will be Asunción and Iguaçu Falls. Asunción is a friendly city of well over one million with a more European flavor than La Paz or Lima. Iguaçu Falls is a series of cataracts and waterfalls on the Paraná River where Paraguay, Argentina, and Brazil come together.

The climate of the area is similar to that of North America and Europe, with migrating high and low pressure systems bringing alternating spells of sunny and cloudy weather.

The combination of good roads and variable weather conditions will give an advantage to eclipse chasers who remain mobile. Weather statistics do not point to any one location in Paraguay as consistently better than others. Our advice here is to scout out several locations beforehand and pay attention to local forecasts. Because this part of the eclipse track is often visited by large and wet low pressure systems, clear skies can be a long way off. Be prepared to travel three hundred to five hundred kilometers at the last minute.

Brazil — Maximum Eclipse on Land

East of Iguaçu Falls the Moon's shadow bumps across a range of hills that grow gradually in height to form the 2,000-meter-high Serra do Mar which guards the coast of Brazil. These coastal mountains impede cloudy cold fronts moving toward the interior of Brazil. As a result, bad weather can linger in the area for days. It is a region with a reputation for cloudy weather and the statistics bear it out. After Mindanao in 1988 and parts of Baja in 1991, there are probably more than a few eclipse chasers who'd prefer to find a site away from coastal mountains. Falling temperatures after first contact have a tendency to promote cloudiness wherever there's a supply of moisture, and seaboard mountains are perfectly located for that.

Nevertheless, Brazil has one magic appeal — four minutes of totality. And sunshine isn't unknown, just a little less likely than in neighboring regions. If you want to roll dice with the weather here, keep an eye on the forecast and be ready to travel, perhaps into Paraguay. Pick up the appropriate visa just in case.

Offshore — A Luxury Cruise

Shipboard cruises have become a popular way to see eclipses in the past two decades. Perhaps it's the mobility, which allows you to find a hole in the clouds without being constrained by mountains and roads. Or possibly it's the food! Compared to a cold night on the Bolivian plateau, the creature comforts of a cruise ship are very attractive. And totality in the South Atlantic lasts over four mintues.

For cruise ships, the best place to be is near the Brazilian coast. Satellite pictures show that offshore weather systems here tend to be patchy with numerous breaks and holes. Guided by weather satellite images, crews should have no problem steering to a suitable spot in time to catch the eclipse. In fact, prospects offshore are probably as good as any location east of the Andes.

Next year's event offers you a chance to experience a total eclipse during a choice of once-in-a-lifetime vacations, from the luxury of an ocean cruise to the adventure of a trek across the lost empire of the Incas. So get out the maps and travel books and make your plans now if you want to return to darkness on November 3, 1994. □

Jay Anderson, a meteorologist with Environment Canada, specializes in eclipse weather forecasts. Ken Willcox is co-author with Mark Littmann of Totality: Eclipses of the Sun *published in 1991 by University of Hawaii Press.*

EYEING THE LOCAL GROUP

Under a dark November sky you can see several of the nearest galaxies with your eyes alone.

by John Mood

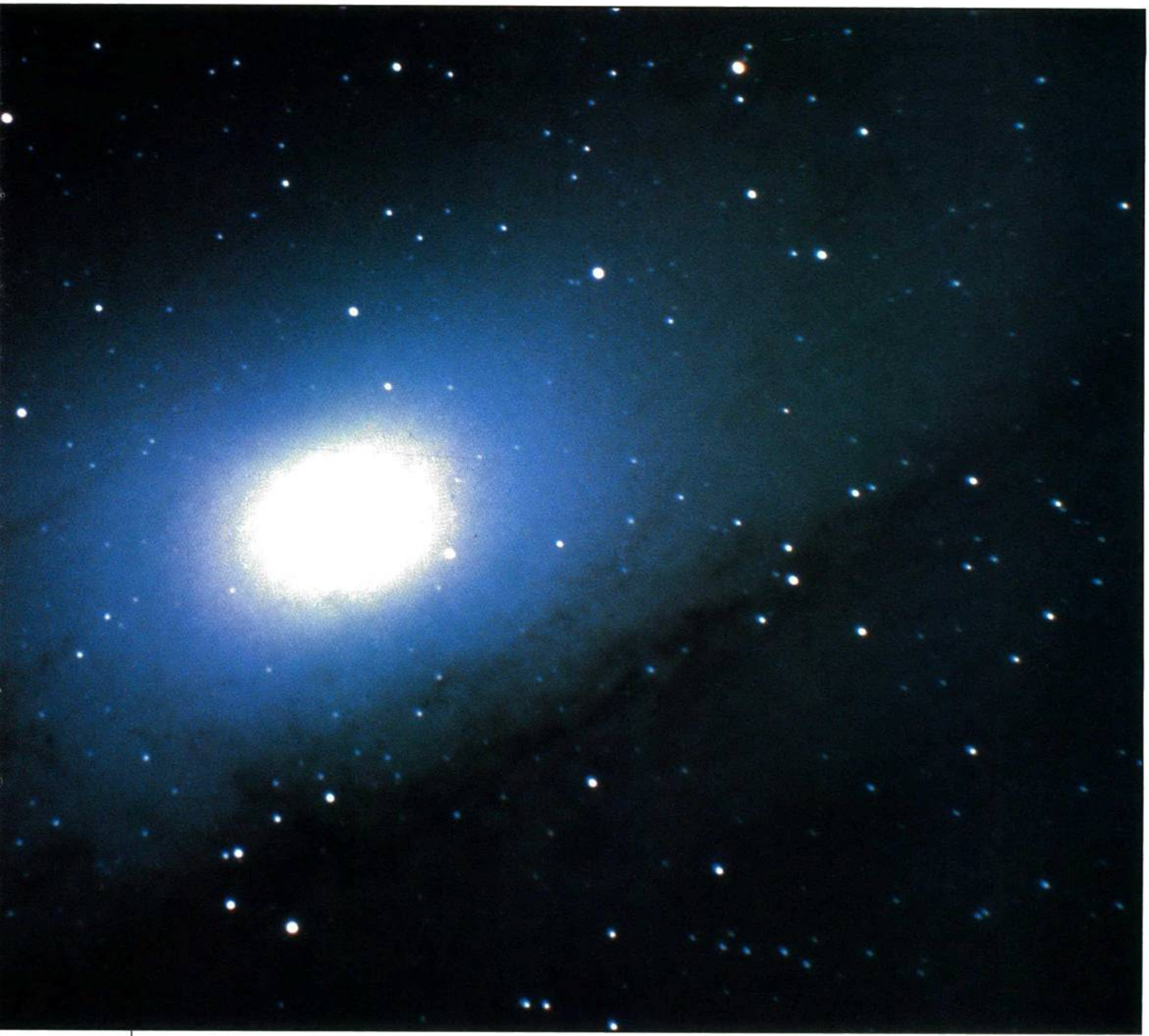
Looking for an observing challenge this November? Try some naked-eye observing of galaxies. Surprisingly, five galaxies are visible to the naked eye. They are the brightest members of the Local Group, the cloud of 32 galaxies that measures about three million light-years across and defines our neighborhood around the Milky Way. (See "Galactic Intruders," page 26).

The challenge isn't for everyone, however. You'll need to have a very dark sky, be relatively familiar with constellations, and be experienced enough in galaxy watching to know just what type of faint fuzzy glow to look for. But even if you do not see all five galaxies by eye alone, you can observe them easily with binoculars or a small telescope.

The easiest of the five challenges is of course our own Galaxy, the Milky Way. Conspicuously arching overhead on winter and summer nights, this fuzzy band of light is the combined light of thousands of stars concentrated in the Galaxy's disk. On a cool winter night you can see the brilliant stars in Orion, Taurus, and Auriga studding the smooth glow of the Galaxy. On a warm spring evening after the Milky Way rises, see if you can visualize the Sagittarius glow for what it is — the cumulative light from tens of thousands of stars that make up a spiral arm of our Galaxy. When we look toward Sagittarius we are looking toward the galactic center. We are not able to see the center of the Galaxy, but instead the next arm closer to the center. On a very dark night the Milky Way from Centaurus through Sagittarius and north into Cygnus appears three-dimensional. The view is unforgettably beautiful because the glow of the Galaxy's star clouds is set against a backdrop of dark nebulosity that is so contrasty the milky glow appears etched into the heavens.

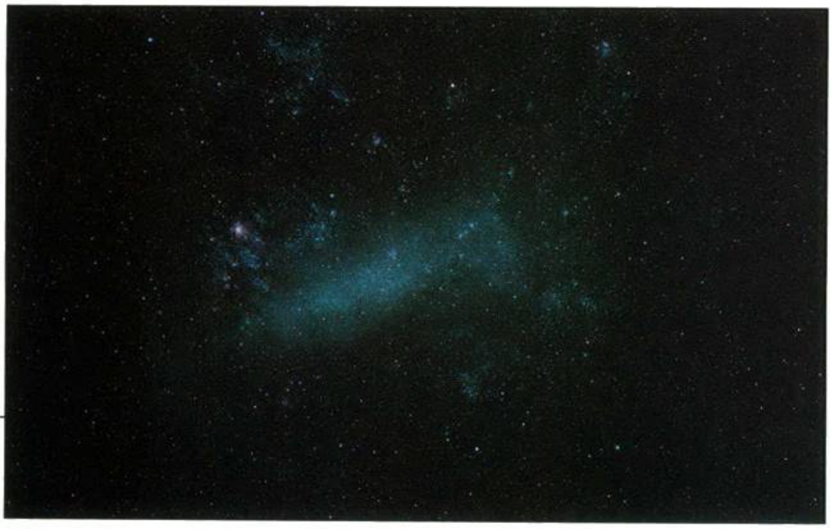
Several galaxies outside our own are also visible without optical aid. Of these, by far the best are two large galaxies lying deep in the southern sky: the Large Magellanic Cloud in Dorado and the Small Magellanic Cloud in Tucana, satellite galaxies of our own Milky Way. They are small, irregular galaxies consisting of several billion stars each that slowly orbit the Milky Way at distances of 170,000 and 205,000 light-years, respectively. Because they are so close, the LMC and SMC appear to the naked eye as glowing patches of hazy light. Their names resulted because early explorers, including Ferdinand Magellan, noted their cloudlike appearance.

With a pair of binoculars the LMC and SMC come alive. The LMC contains many clumps and knots of stars and nebulae which, because the galaxy is so close to us, we

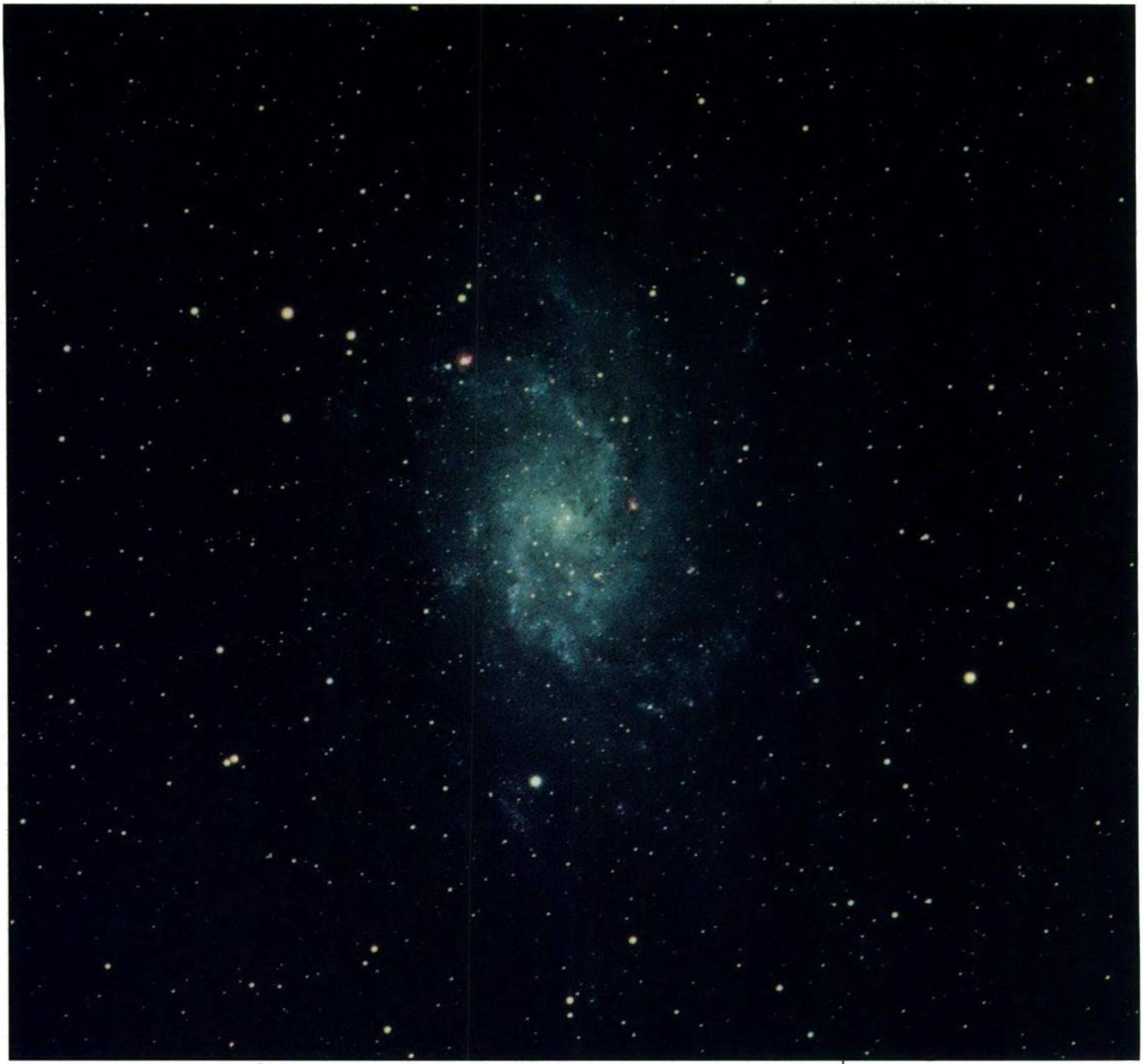


The Andromeda Galaxy
Mag. 3.5, size 178' by 63'
Photo by John P. Gleason

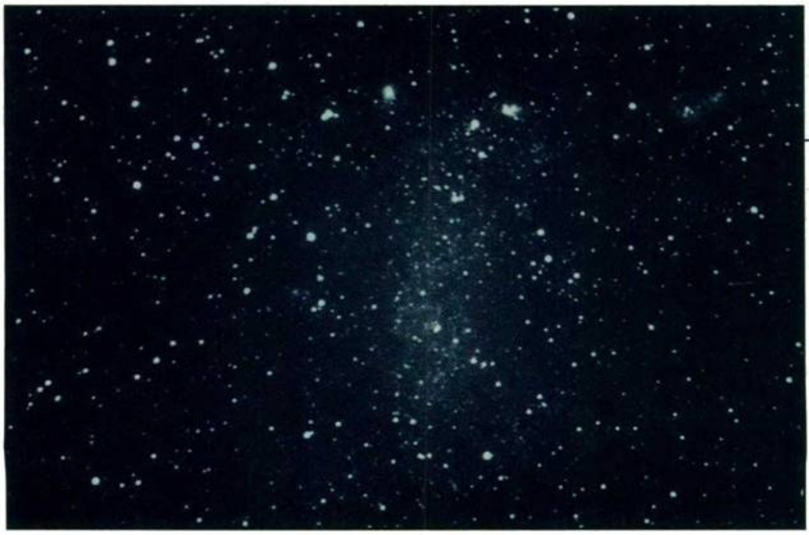
The Small *Magellanic* Cloud
Mag. 2.3, size 280' by 160'
Photo by Luke Dodd



The Large Magellanic Cloud
Mag. 0.1, size 650' by 550'
Photo by Luke Dodd



M33
Mag. 5.7, size 62' by 39'
Photo by Mike Simmons



NGC 6822
Mag. 9.4, size 10.2' by 9.5'
Photo by Chuck Vaughn

NGC 205
Mag. 8.0, size 17.4' by 9.8'
Photo by Martin C. Germano

NGC 147
Mag. 9.3, size 12.9' by 8.1'
Photo by Harvey Freed

NGC 185
Mag. 9.2, size 11.5' by 9.8'
Photo by Kim Zussman

can see rather easily. The Tarantula Nebula (NGC 2070) is the brightest stellar birthplace in another galaxy — it is visible in binoculars north of the LMC's eastern end. The SMC also contains star clouds visible in binoculars or a small scope and lies in the same field of view as two bright globular clusters in our own Galaxy, 47 Tucanae and NGC 362.

Those not fortunate enough to observe the southern skies can turn their eyes to another Local Group member that is an easy naked-eye object these evenings. The Andromeda Galaxy (M31), physically the largest galaxy in the group, can be seen on any dark autumn evening. Located at a distance of 2.5 million light-years, the Andromeda Galaxy is the Milky Way's sister spiral. If you go out to observe the constellation Andromeda and wait a few minutes until your eyes are dark adapted, you'll see the Andromeda Galaxy as a misty streak of light northeast of the Great Square of Pegasus. (It lies about 12° — the width of your palm held at arm's length — northeast of the Square's northeast corner.) A pair of binoculars shows the galaxy as a bright nucleus surrounded by an oval haze measuring 2° long.

Telescopes centered on the Andromeda Galaxy show not only the galaxy's bright hub sculpted by dark lanes, but also two satellite galaxies. These are M32 (NGC 221) and NGC 205. These galaxies orbit Andromeda's big spiral much the same way the Magellanic Clouds orbit our own Galaxy. But Andromeda's companions are tiny elliptical galaxies with well-defined shapes. Our companions are six to eight times larger and their stars are scattered in chaos — they lack the symmetry of the ellipticals. The Andromeda Galaxy has its gravitational grip on two more small elliptical galaxies that lie several degrees away in the constellation Cassiopeia. NGC 147 and NGC 185 are faint enough to require a 6-inch telescope to be seen.

The Local Group contains a third spiral, this one considerably smaller in diameter and mass than the Andromeda Galaxy and the Milky Way. M33 (NGC 598), in the constellation Triangulum, is sometimes called the Pinwheel Galaxy for its distinctive spiral pattern. At magnitude 5.7, M33 is a naked-eye challenge. Observers under a dark sky and with good seeing and transparency can glimpse M33 without optical aid, but the observation is a tough one. Binoculars or a low-power telescope do a much better job of showing this object, which has a notoriously low surface brightness. Its total magnitude is pretty bright, but the galaxy is spread over such a large area that little parts of it appear dim.

Other, fainter galaxies round out our Local Group. These include the irregular galaxies NGC 6822 in Sagittarius and IC 1613 in Cetus, the lenticular galaxy Maffei I in Cassiopeia, and the dwarf ellipticals in Leo, Sculptor, Fornax, Draco, and Ursa Minor. Most of these objects are challenging targets for experienced backyard observers.

From our perch midway out in a spiral arm of the Milky Way we have a good position to observe these neighbors. So this autumn, take a look and let Astronomy know about your successes, whether they be with eyes alone, binoculars, or a telescope. □

John Mood is an amateur astronomer and freelance writer living in San Diego. His last article, "The Mexican Sun Dance," written with his wife Stephanie, appeared in the November 1991 issue.

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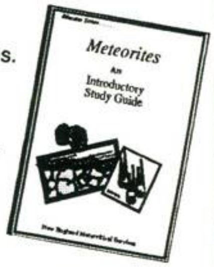

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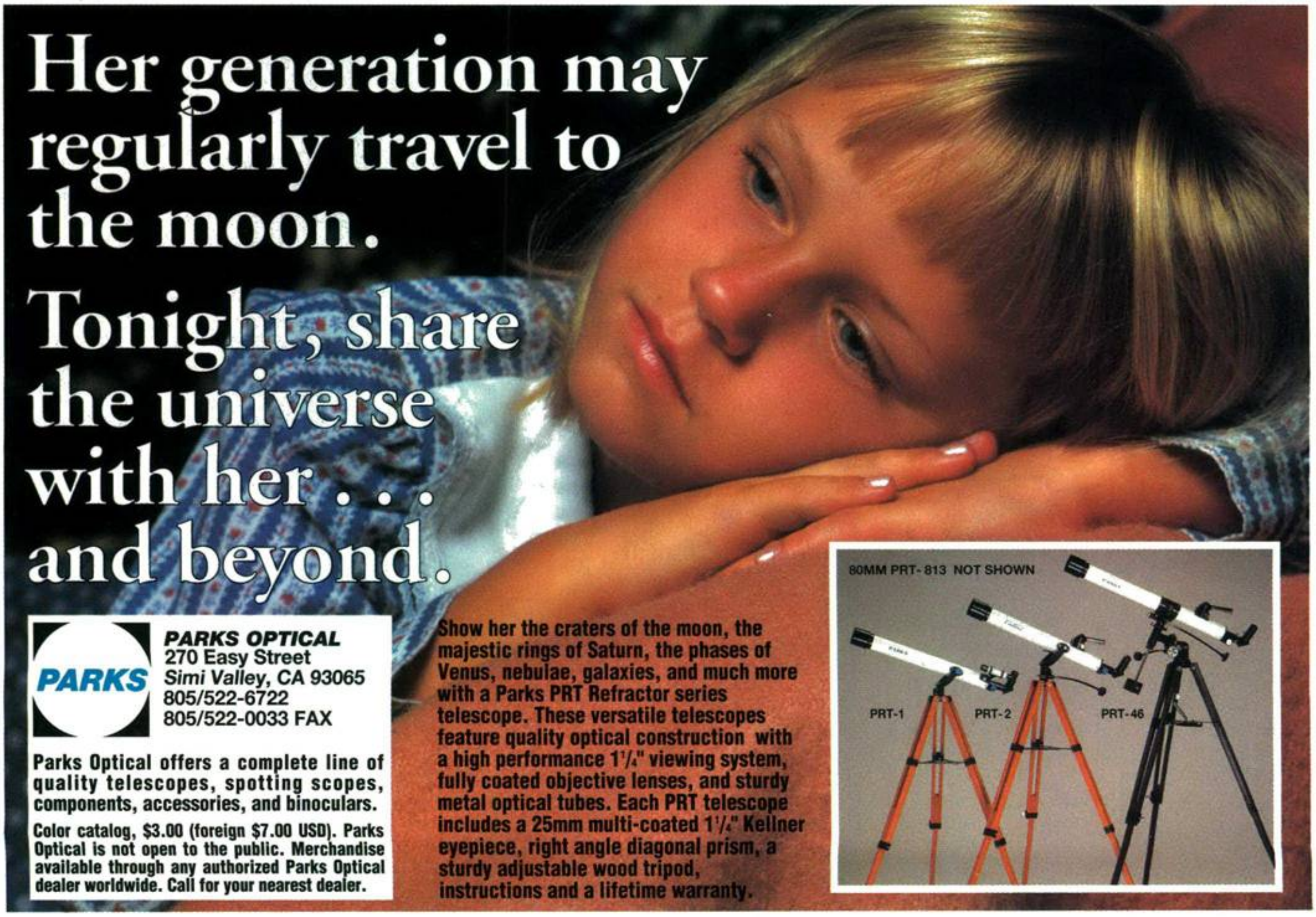
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GIVE IT YOUR FIRST SHOT

Christos Frantzolas became an amateur astronomer with such high hopes. A resident of Ermióni, Greece, Frantzolas acquired a love of the night sky and shortly thereafter a 10-inch telescope. Then he set out to explore the heavens.

One evening the enthusiastic skywatcher attached his 35mm SLR camera to the telescope's mounting. Frantzolas had never before taken a picture of the sky. Yet his camera, loaded with Kodacolor Gold 400 film, beautifully recorded the splendor of the Milky Way in Sagittarius in a 10-minute exposure. He used an 80mm lens at f/1.7.

Frantzolas' story underscores the ease with which amateur astronomers can now photograph the sky. Over the past four or five years the quality and speed of some off-the-shelf films have increased dramatically, as has the sharpness of many camera lenses. We are now firmly in an era when a backyard astrophotographer's first image can be quite pleasing. The old struggle-for-years apprenticeship is, to everyone's delight, fading to black.

Jupiter's Belts and Bands. Mighty Jupiter was clearly the most watched planet during the first half of 1993. It is likely to remain the target of many telescopes as Comet Shoemaker-Levy 9 approaches the huge planet over the next several months and collides with it in July 1994.

On May 14/15 John Sellechio of Warwick, Rhode Island, observed Jupiter with his 10-inch f/4.5 reflector at 146x. Says Sellechio, "To my surprise I was able to witness not only the Great Red Spot for the first time but also a shadow transit." Christopher Tobias of Racine, Wisconsin, made several sketches of Jupiter in April and May. His drawings of May 10, made with a 14-inch SCT at 326x, show the Great Red Spot, several white spots north and south of the South Equatorial Belt, and festoons associated with several of the planet's major belts.

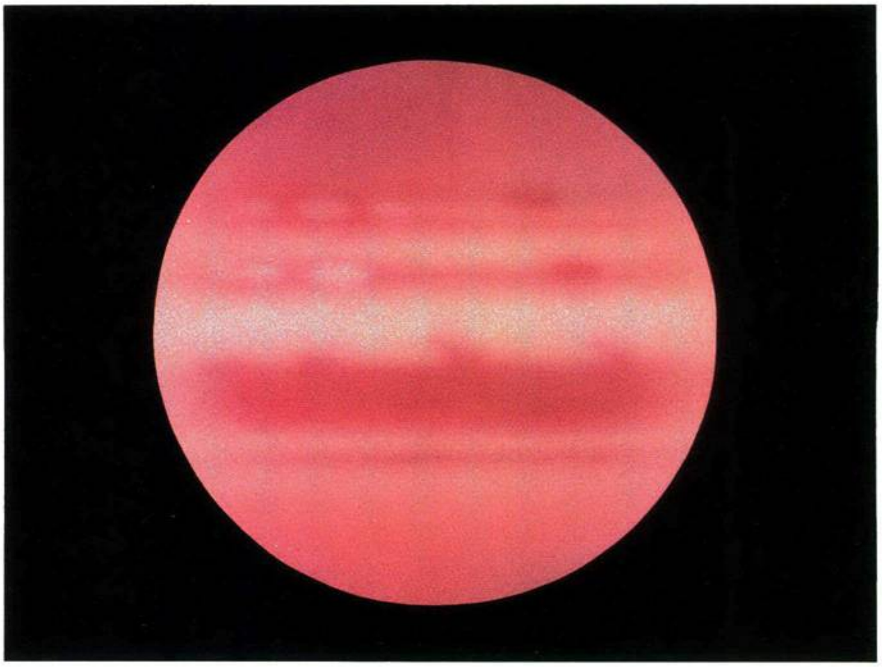
During that period the planet's South Equatorial Belt appeared much lighter than it normally does. Additionally, the belt gave rise to an eruption of cloud activity that sprang from the region and over short time intervals spread north and south. On April 9, Jim Tomney of Towson, Maryland, sketched the planet with his 6-inch f/8 reflector at 124x. Tomney observed a circular spot with material "bleeding off to the west" positioned within the faded belt.

Klaus Brasch of Highland, California, reports that this eruption quickly restored the faded belt. "It faded in 1992 and was still a ghost of its former self in April 1993," says Brasch. Early in April the belt erupted, however, spreading material through the planet's cloud layers and re-establishing the old familiar appearance. "I was fortunate enough to observe Jupiter on April 25," he says, "when the belt appeared like a series of pale blue patches that hadn't yet merged into a continuous band. The patches looked like brush strokes preceding the nearby orange-pink Red Spot. I was using a 14-inch SCT at 300x to 400x on an exceptionally good night."

The belt returned in time for a new Jovian peculiarity, the predicted freak collision of the fragmented comet Shoemaker-Levy 9 with the planet next summer. Stay tuned for more on the king of planets. □

THE FIRST ATTEMPT at astrophotography by Christos Frantzolas produced a pretty shot of the Milky Way in Sagittarius. With better, faster films, good results are far easier to achieve than they were a few years ago.

ASTRONOMY wants to hear about your observations of the sky. Please send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187.



THOUSANDS OF PLANETARY OBSERVERS closely watched Jupiter during the first half of 1993, looking for details like those in Edwin Faughn's sketch. Next summer the planet's clouds may be disturbed by the impact of Comet Shoemaker-Levy 9.

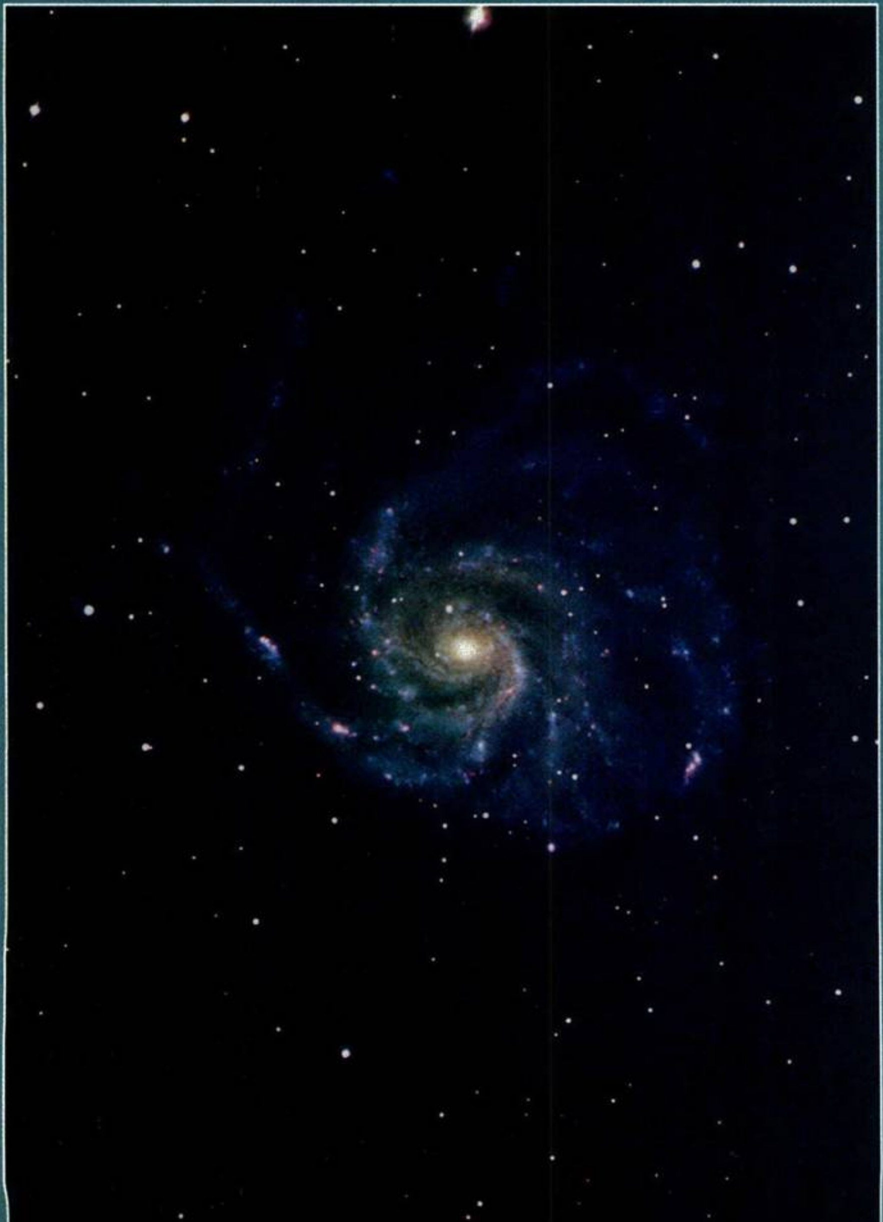
KECK COMES ALIVE

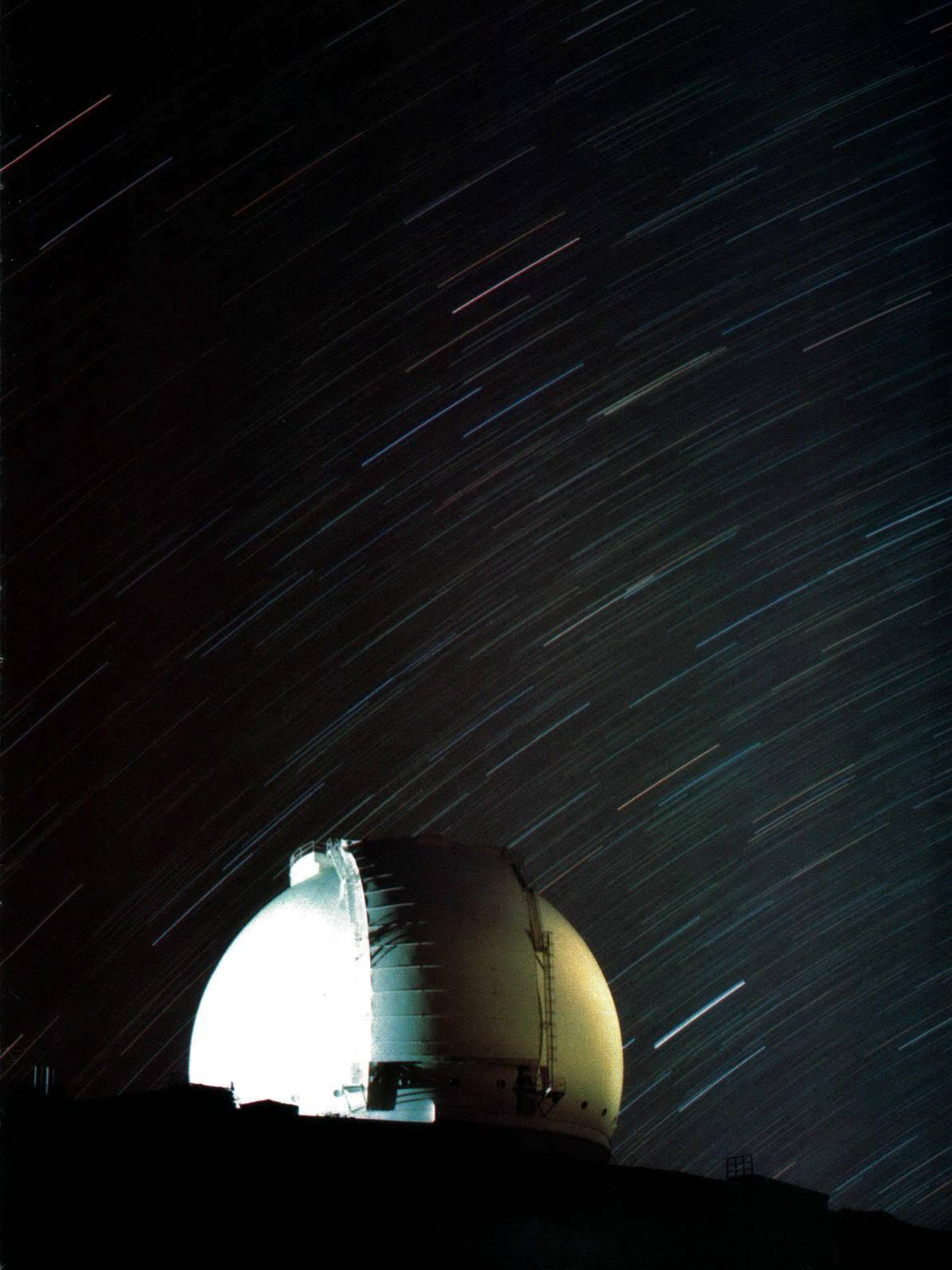
Now fully operational, the 10-meter Keck telescope on Mauna Kea, Hawaii, is beginning what astronomers hope will be a long and distinguished record of astronomical discovery. To create an inaugural portrait of the world's largest telescope, Russell Underwood photographed the Keck dome underneath stars trailed by Earth's rotation. Underwood's photo (opposite page) wins this month's $100 Best Astrophoto award.

In another exercise in scenic beauty, Joshua T. Vaughan captured a ruddy aurora over Sedona, Arizona, in 1989 (left). Focusing on the source of such auroral activity, Milan Kamenicky of Tepla, Slovakia, recorded a huge eruptive prominence on the Sun on September 6, 1989 (bottom).

Looking beyond the solar system, Californians Bill and Sally Fletcher produced a tricolor image of the galaxy M101 in Ursa Major (below left) by making three monochromatic filtered exposures and combining them in the darkroom.

Bob Sandy's shot shows an old friendly constellation slowly returning to the evening sky (below). In addition to the bright stars of Orion, Sandy's photo shows the Orion Nebula and, at upper left, the Rosette Nebula in Monoceros.





THE BRILLIANT BLUE of the Pleiades cluster in Taurus comes from tiny grains of dust that surround the bright stars and reflect their light toward us. George Greaney captured the beauty of this cluster with his 5-inch refractor and a composite image of two 50-minute color exposures.

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FOR SALE — Issues of ASTRONOMY, *Sky & Telescope*, *Popular Astronomy*, *Star & Sky*, *Cosmic Search*, and others, including first issues, (300 total) $250 includes shipping. Send SASE for complete list. Contact H.P. Porter, Postmaster, Long Branch, TX 75669-9998.

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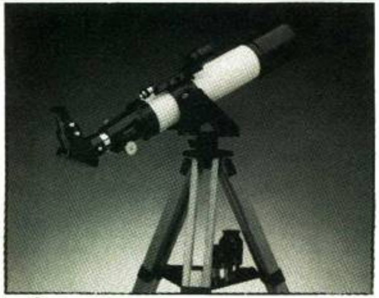

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Mars, by Peter Cattermole, (Chapman and Hall, 1992), ISBN 0-412-44140-3, 224 pages, hardcover, $35.

Cattermole portrays the Red Planet in great detail, describing its orbit, seasons, atmosphere, interior, volcanos, canyons, and polar regions. Many maps and images, primarily those obtained with the Viking spacecraft, illustrate the points he makes about Martian geology. An appendix describes Mars' two moons, Phobos and Deimos. Written for the general public, *Mars* provides a good overview of what we know about the planet.

Solar System Evolution, by Stuart Ross Taylor, (Cambridge University Press, 1992), ISBN 0-521-37212-7, 307 pages, hardcover, $49.95.

How did planets form from the gas and dust surrounding the fledgling Sun? *Solar System Evolution* describes this process. But it does more than just describe in general terms the events that created our planetary system. Taylor starts with the Big Bang and traces the chemical evolution of the universe and our Galaxy, in particular. He also uses the chemistry of Earth and the Moon to interpret what the early solar system was like.

Rendezvous in Space, by John C. Brandt and Robert D. Chapman, (W. H. Freeman and Co., 1992), ISBN 0-7167-2175-9, 291 pages, hardcover, $23.95.

Astronomers' observations of Comet Halley during its 1985-1986 passage through the inner solar system helped revolutionize cometary science. This book describes improvements to Whipple's "dirty snowball" model of a comet's nucleus, the nature of cometary tails, and the origin of comets in the farthest reaches of our solar system, the Kuiper belt and Oort cloud. Brandt and Chapman finish by discussing future space missions to comets, such as the European Space Agency's Rosetta. An appendix includes PASCAL and GW-BASIC programs to help you calculate the positions of comets.

A View of M31

The Andromeda Galaxy, by Paul Hodge, (Kluwer Academic Publishers, 1992), ISBN 0-7923-1654-1, 358 pages, acid-free paper, hardcover, $79.

The Andromeda Galaxy, also known to backyard astronomers as M31, is the nearest large spiral galaxy and one that is much like our own. Because of its proximity, astronomers have studied M31 in great detail. Although Hodge gets technical at times, his book summarizes information about the galaxy in a manner that should be accessible to advanced amateurs. He describes the galaxy's star clusters, dust lanes, variable stars, supernova remnants and planetary nebulae. The many images and line drawings will help readers better visualize this giant spiral and the stars, gas, and dust it contains.

Observing Handbooks

Observer's Handbook 1994, edited by Roy L. Bishop, (Royal Astronomical Society of Canada, 136 Dupont Street, Toronto, ON M5R 1V2, Canada, 1993), 238 pages, softcover, $15.89; $17 Canadian.

This useful collection of astronomical information is a perennial favorite of backyard astronomers. It lists information (updated annually) about comets, meteor showers, asteroid positions, Moon rise and set times, lunar and solar eclipses, occultations, planetary phenomena, Jupiter satellite eclipses and transits, configurations of Saturn's satellites, and more. The handbook also contains tables of double stars, variable stars, star clusters, nebulae, galaxies, Messier objects, the finest NGC objects, and deep-sky challenge objects. And it has maps of the Moon and night sky and figures showing the named features of Jupiter's atmosphere and Saturn's rings.

Finder Charts of the Messier Objects, by Brent Watson, (Sky Spot, 1263 East Beverly Way, Bountiful, UT 84010, 1993), $16.95 per volume, $29.95 for the set. Volume 1 includes M1 through M55 and Volume 2 M56 through M110.

Finding Messier objects is easy with these finder charts. Watson used a computerized planetarium program (TheSky) to produce these high-quality maps. They show three circles on the map to help you locate the object. The circles match the rings in a Telrad finderscope. Facing each map is a description of the object, including its magnitude, distance, and angular size. The pages are waterproof for use at the telescope.

Sky Watcher's Handbook, edited by James Muirden, (W. H. Freeman and Co., 1993), ISBN 0-7167-4502-X, 408 pages, hardcover, $35.

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techniques should take a look at this book. Muirden found eighteen well-known amateurs willing to share their observing experience and techniques: They include, for example, Peter Taylor on observing the Sun, David Levy on comet hunting, Fred Pilcher on asteroids, John Westfall on lunar observing, Glenn Chaple on double stars, and Gérard Therin on astrophotography. Other chapters describe observing the planets, meteors, variable stars, novae and supernovae, and getting started in photometry and video-CCD astronomy. Many of the authors include a reference and resource list at the end of their chapter to lead you to equipment suppliers, helpful charts and atlases, and amateur organizations that specialize in that field of astronomy.

Astronomical Anthropology

Conversing with the Planets, by Anthony Aveni, (Times Books, 1992), ISBN 0-8129-1975-0, 255 pages, hardcover, $21.

Subtitled *How Science and Myth Invented the Cosmos,* this book explores the cultural contexts within which ancient astronomers developed their views of the universe. Aveni stresses the harmony these skywatchers wished to create between their beliefs and their knowledge of the sky. Instead of deriding star myths as merely amusing stories, he suggests that stories can help us learn how we have become who we are.

Other Books Received

The Astronomical Revolution, by Alexandre Koyré, (Dover, 1992), ISBN 0-486-27095-5, 531 pages, softcover, $11.95. A translation into English by R. E. W. Maddison of Koyré's 1961 book on the writings of Copernicus, Kepler, and Borelli. The book includes many reproductions of the orbital drawings by the three astronomers.

The Sky in Mayan Literature, edited by Anthony Aveni, (Oxford University Press, 1992), ISBN 0-19-506844-0, 297 pages, acid-free paper, hardcover, $39.95. Eleven anthropologists and other experts discuss Mayan codices, calendars, almanacs, and skywatching.

Research Amateur Astronomy, edited by Stephen J. Edberg, (Astronomical Society of the Pacific, 1992), ISBN 0-937707-52-X, 267 pages, hardcover, $44.50. The proceedings of the symposium on astronomical research by amateurs held in La Paz, Baja California Sur, in July 1991. □

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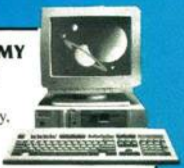

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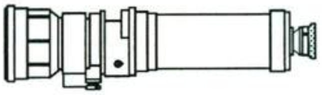

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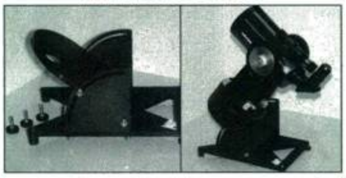

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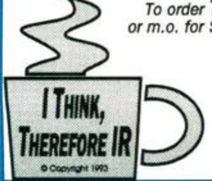

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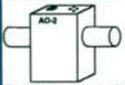

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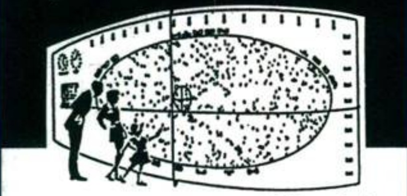

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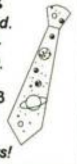

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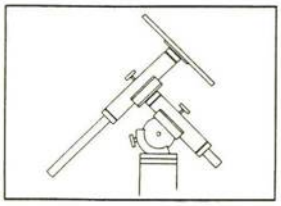

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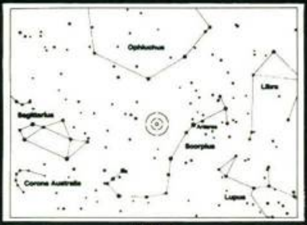

M19

NGC Description: Globular cluster, very bright, large, round, very compressed toward the middle, extremely resolved.

M19 was discovered by Charles Messier in 1764. It is a small but easily resolved globular cluster. It is also one of the more oblate clusters. M19 is in Ophiuchus, a constellation known for its many globulars.

M19 is small and lies only 3,000 light years from the center of the Milky Way. It is about 33,000 light years from us.

NGC	TYPE	MAG.	DISTANCE	SIZE	DIAMETER
6273	Gb	7.2	33,000 l.y.	14'	134 l.y.

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Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00

40mm to 80mm Binoculars - Mounted .... $92.00 pr.

GLASS - *TYPE 2* *(Full Aperture)*

Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
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10"	139.00	10"	119.00
11"	149.00	11"	139.00
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40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS - *TYPE 3* *(Full Aperture)*

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5 to 4"	79.00
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Threaded camera filters also available.

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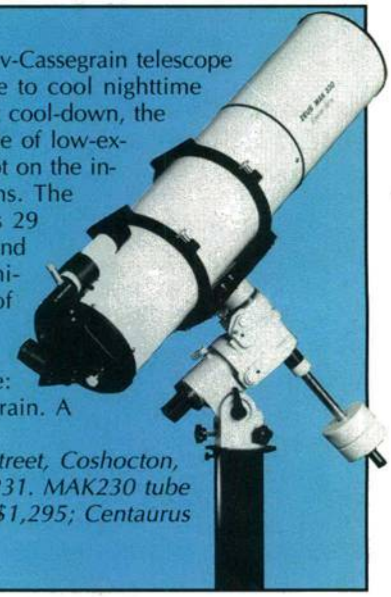

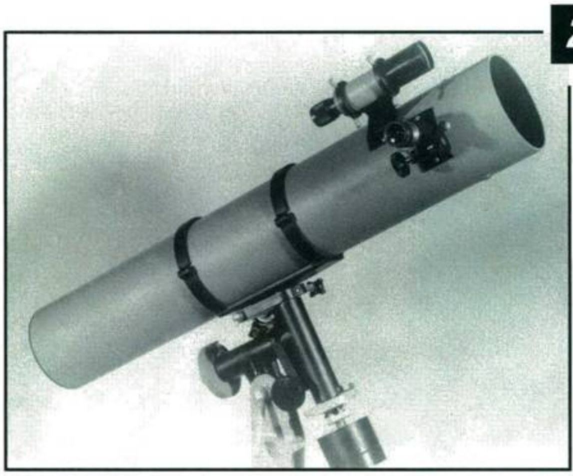

2 Cosmotron Reflectors

Europtik Ltd. has announced their line of "Cosmotron" Newtonian reflector telescopes ranging in apertures from 2.6 inches to 12 inches. (The 4.5-inch model is shown.) The 2.6-inch uses an altazimuth mount; all others come with a German equatorial mount and a full range of accessories.

Europtik Ltd., P.O. Box 319, Dunmore, PA 18512, (717) 347-6049. Write for free catalog and price list.

3 New Starsplitter Dobsonians

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Starsplitter Telescopes, 3228 Rikkard Drive, Thousand Oaks, CA 91362, (805) 493-2489. 14.5-inch: $2,795; 16-inch: $3,195; 18-inch: $3,495; 20-inch: $3,995; 25-inch: $8,095. Price for 30 inch to be announced.

(continued on page 114)

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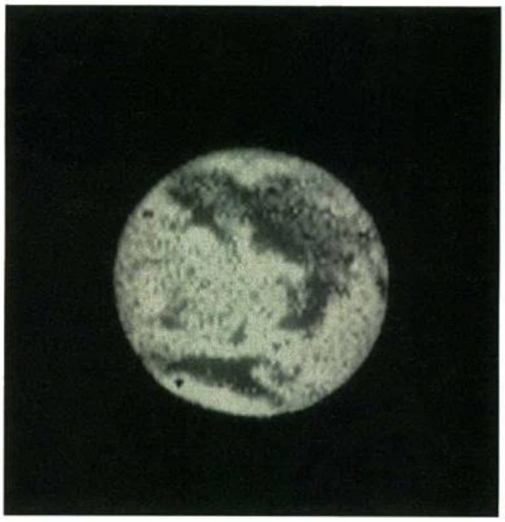

Mars. *Eleven 0.11 second CCD images summed together at the prime focus of an 8 inch refractor with an effective focal length of 923 inches. Courtesy AMSEE, France.*

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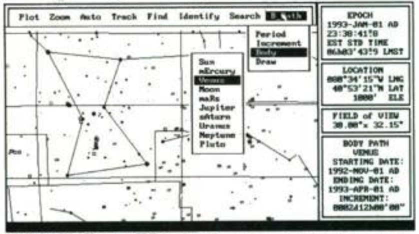

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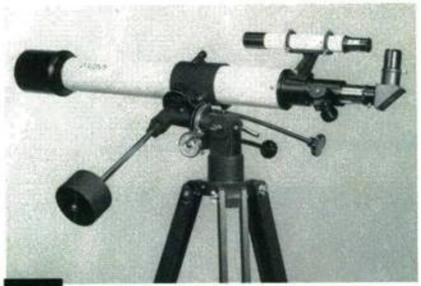


4 Parks 80mm Equatorial Refractor

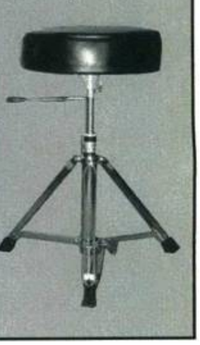
The Parks PRT-813 is an 80mm f/11 refractor featuring a German equatorial mount with wood tripod, slow-motion controls, and setting circles. A 6x30 finderscope and 1.25-inch focuser are standard. A clock drive is optional.

Parks Optical, 270 Easy Street, Simi Valley, CA 93065, (805) 522-6722. $1,100.

5 Tele Vue Air Chair

Operated by a pneumatic piston, the Air Chair's height can be adjusted from 20 to 25 inches while you remain seated. The height adjustment lever rotates 360° with the padded seat so the lever is always at your fingertips.

Tele Vue Optics, Inc., 100 Route 59, Suffern, NY 10901, (914) 357-9522. $130.



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1994 Weekly Calendar

6 Astronomy Engagement Calendar

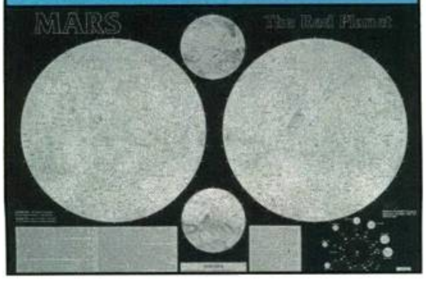
Starry Messenger Press has introduced a 1994 weekly engagement calendar and appointment book. Each week's pages include a color space-program image or astrophoto, Moon phase graphics, night sky information, and notes of space exploration anniversaries.

Starry Messenger Press, P.O. Box 6422, Ithaca, NY 14851, (607) 277-6836, fax (607) 277-2698. $12.95 plus $2 shipping and handling.

7 Edmund Scientific Mars Map

This 26" by 38" poster designed by Antonín Rükl and George Lovi identifies all the major surface features on Mars as well as provides basic astronomical information about the Red Planet.

Edmund Scientific Co., Dept. 13A1, C999 Edscorp Building, Barrington, NJ 08007, (609) 547-8880. Poster stock: $9.95; plastic stock: $14.95.



8 Backlit Photo Frames

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Light Quest, 7058 Murietta Avenue, Van Nuys, CA 91405, (818) 376-0774. Prices available from manufacturer.

(continued on page 118)

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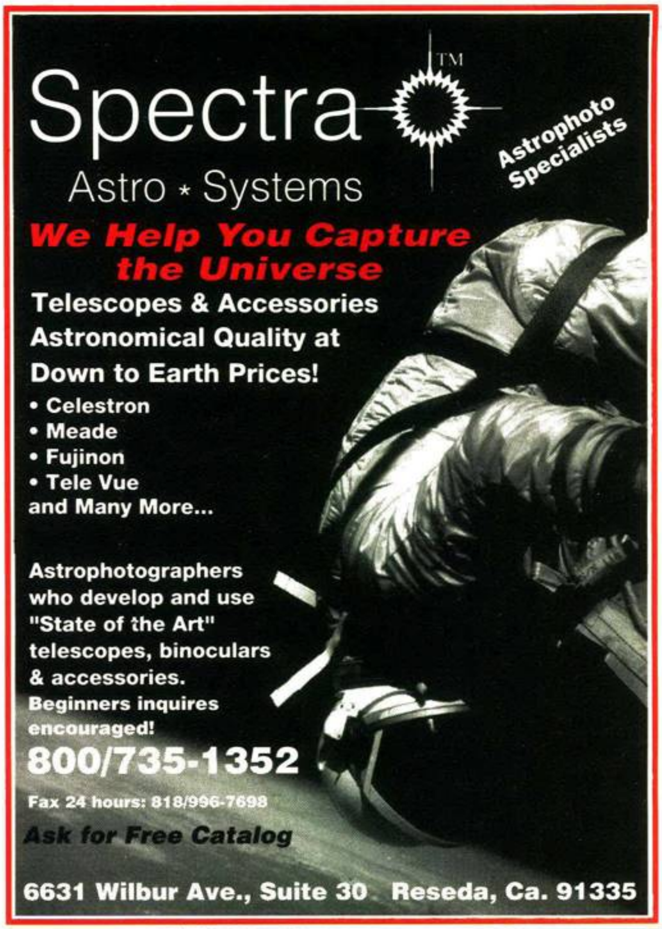

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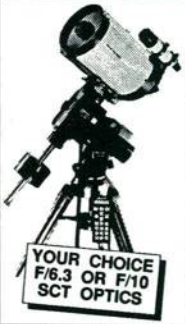

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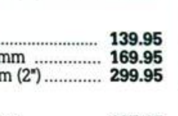

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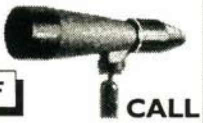

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9 Astrophoto Posters

Josh Vaughn Photography has released a set of four high-quality color posters depicting night sky scenes over landscapes in southwestern United States. They include Josh Vaughn's *Saguaro Star Trails* (shown) and *Lightning over Sedona* and Michelle Breedlove's *Circumpolar Star Trails over Sedona* and *Aurora over Sedona*. All measure approximately 18" by 22" and are printed on heavy stock.

Josh Vaughn Photography, P.O. Box 450, Sedona, AZ 86336, (602) 282-6463. Josh Vaughn posters: $9.95 each; Michelle Breedlove posters: $15.95 each.

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10 Equipment Cases Designed for Travel

New equipment cases from Porter Case incorporate wheels and a handle for quick conversion into a luggage cart. The Model I measures 22"x11.75"x7.75"; the Model II measures 22"x14"x8", the largest allowable carry-on size for airline luggage. Both feature black ABS plastic construction and can be fitted with precut foam interiors.

Porter Case, Inc., 122 Callander Drive, South Bend, IN 46614, (219) 291-0902, fax (219) 291-1244. Model I: $190; Model II: $210. Shipping extra.

11 Euro Value Binoculars from Europtik

The Euro Value series of porro prism binoculars consists of 8x30, 7x35, 8x40, 12x40, 7x50, 10x50, 15x50, and 20x60 (depicted) models. Each features metal body construction and high-performance European-made optics.

Europtik, P.O. Box 319, Dunmore, PA 18512, (717) 347-6049, fax (717) 969-4330. $195 to $395.

12 New Telescope User's Video

A 30-minute video from Group K Productions called *Using Astronomical Telescopes and Accessories* covers using an equatorial mount, polar alignment, and setting circles, selecting eyepieces and filters, star-hopping techniques, safe solar viewing techniques, choosing binoculars, and doing basic astrophotography.

Group K Productions, 3243a Dufferin Street, Toronto, Ontario, Canada M6A 2T2, (416) 783-4140, fax (416) 783-7697. $39.95 plus $3.50 shipping. ☐

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to ASTRONOMY*, New Products Editor, P.O. Box 1612, Waukesha, WI 53187-1612.*

READER'S EXCHANGE

FOR SALE — Standard 3$^1/_2$" Questar, with case and P adapter. Contact Ed Case, 4495 Peidras Street, Cocoa, FL 32927, (407) 633-1090.

FOR SALE — C8 with tripod, wedge, 8x50 right angle finderscope, 12V converter, 40mm Super Plössl, 25mm Kellner, 16mm and 8.8mm Naglers, Barlow, LPR filter, case, and includes Nikon camera with intenscreen, adapter, T-ring, off-axis guider, balance system, and illumination reticle. All like new, $1,195. Contact Lee Keith (414) 425-2331.

FOR SALE — 6" refractor, f/10 tube assembly, 2" focuser, Dobbins lens, $750; ASTRONOMY (1973-1992) magazines in good condition, however 14 issues are missing, $100 or best offer. Contact Mike (602) 297-2781, evening.

FOR SALE — Meade #323, 80mm (3.1") equatorial refractor, $350; Celestron 20x80 binoculars with tripod adapter, $200. Both items are like new. Contact George Bourke, 1002 S. Thompson, Jackson, MI 49203, (517) 783-3803.

WANTED — 6" Orion Dobsonian with eyepiece and precision focuser. Contact Joe Learned, 3412 Hayes Street, NE, Minneapolis, MN 55418, (612) 781-2312.

FOR SALE — ASTRONOMY, (March 1974-June 1978), in good condition, $50. Contact David, (516) 496-9000.

WANTED — Amateur astronomer invites others to share expenses between May and July 1994 for a trans-Australian camping tour. Am traveling with an 8" SCT, and am familiar with the southern skies, folklore, and terrain. Contact Robert McDonald, Big Badja Studio-Observatory, Numeralla, 2630 Australia.

FOR SALE — Celestron SPC 90 F fluorite refractor. Super Polaris mount, dual-axis motor drive/corrector (DC), five eyepieces, filter set, complete photographic accessories, tele-extender, and hand-rubbed hardwood tripod, $1,999. Also ASTRONOMY and *Sky & Telescope* magazines. Contact Michael Savage, 5960 Canyon Ferry Road, Helena, MT 59601, (406) 475-3103.

ANNOUNCEMENT — The Ancient City Astronomy Club meets on the first Friday of each month at 8 p.m. in the First United Methodist Church at King Street and Riberia Street in St. Augustine, Florida. Contact ACAC, P.O. Box 546, St. Augustine, FL 32805-0546, (904) 797-5704 or (904) 471-3054.

FOR SALE — Five Brandon Orthoscopic Oculars in formica box, $225 postage paid. Tripod for binoculars, $75, postage paid. TeleVue Renaissance 4" refractor, $700 postage paid. All items in mint condition. Contact Omar Zuhdi, 2303 Robinwood Place, Shawnee, OK 74801, (405) 275-6052.

FOR SALE — Purus Astro-Mechanism clockwork rotation mechanism for astrophotography (Northern Hemisphere), R.A. ±15" per hour, $130 plus shipping. Contact M. Seman, 4601 W. Touhy Avenue, Lincolnwood, IL 60646.

FOR SALE — Meade 2045 with case, 4" f/10 with 110V drive, diagonal prism, 25mm eyepiece, and table tripod legs, $425. Also 43" field tripod with wedge, $75. Contact Max Minniear, (803) 383-4434 evenings.

FOR SALE — Meade 8" SCT with MCOG lens coatings, NGC Max computer (locates 12,100 objects) with new 12k chip, Motofocus, five Plössl parafocal eyepieces, dew zapper, carrying cases for scope and all accessories, plus more, excellent condition and only three years old, $1,850. Contact Sam Nothman, 4690 Cooley Lake Road, Commerce, MI 48382, (313) 684-5653.

FOR SALE — Recently published books on advanced astronomy, astrophysics, physics, mathematics. Most hard cover, 70 titles, $4 each plus shipping. Write for a list. Contact John O. Boyd, 6611 Burkett Street, Houston, TX 77021, (713) 747-8315.

FOR SALE — Meade .965" camera adapter never used, $25; Celestron 18mm .965" Kellner eyepiece, $10; Celestron .965" nebular filter hardly used, $20. Contact Troy Mills, 917 S. Alverno Road, Manitowoc, WI 54220, (414) 758-2161.

FOR SALE — Complete set of ASTRONOMY (1973-1993), $250/best offer. Contact Daniel Conner, 381 Marion Lane, Eugene, OR 97404, (503) 461-4198.

FOR SALE — *The Strolling Astronomer* (Journal of the Association of Lunar and Planetary Observers) July/ August 1964 - March 1991, 56 issues, $50 plus shipping. Contact Steve Farkas, 1008 Old Farm Trail, Medina, OH 44256-2155.

WANTED — Back issues of *Sky & Telescope* from September 1967, any from 1968, 1969, 1982, 1983, 1985, 1986, and 1987. Must be in good condition. Contact Steve Breutzmann, 4481 S. 114th Street, Greenfield, WI 53228.

FOR SALE — Odyssey 8" Dobsonian reflector with 20mm Erfle eyepiece and a Telrad with a hinged dewcap, $200 pick-up only. Contact Bob Kuplin, 1228 Towncrest Road, Williamsport, PA 17701.

WANTED — Theories on quasars. Contact Ben Nolting, P.O. Box 511, Palmer, AK 99645.

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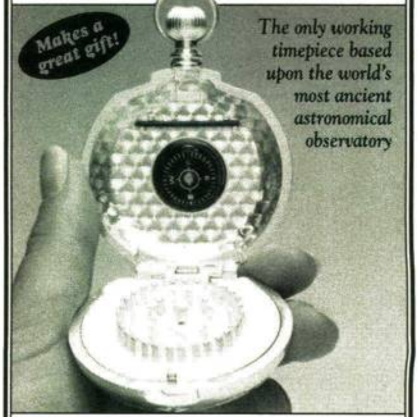
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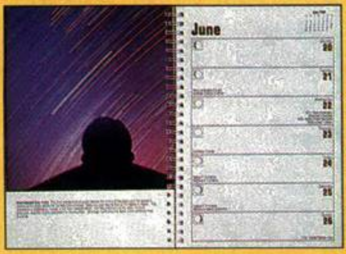

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NEW SOFTWARE ROUNDUP

***Imagine-32 (version 3.0)**, CompuScope, 3463 State Street, Suite 431, Santa Barbara, CA 93105, (805) 966-7179. Price: $299. Minimum requirements: 80386-based computer, math coprocessor, 4 MB of memory, mouse, SVGA display, and a hard disk. A professional version is also available for $699 and a school version for $149. Dial into their BBS at (805) 966-2160 to obtain a demo version of the programs.*

Imagine-32 (last reviewed in the October 1992 issue) now allows you to merge three images to form tricolor images. A "blink" mode alternates the view between two images and you can make movies from a series of images. Input formats include FITS, ST4, ST6, Lynxx, GIF, ARN, IMG, and NASA's IMQ and IBG. You can save images in the TIFF format. A photometry function allows you to measure the brightnesses of stars. The professional version supports generic binary file input and fast Fourier transform analysis.

A special version of Imagine-32 is available that will control a telescope, take a CCD image, and analyze the image, all within one software package. This program is called **Personal Observatory** (version 3.0) and costs $399 ($100 upgrade from Imagine-32 version 2.42). You set the coordinates of the object you want to view and the program moves your Meade LX-200 or SSC telescope to the object. You can take an image with a Santa Barbara Instrument Group ST-4 or ST-6 CCD camera using the camera controller and then analyze the image by applying the commands contained in Imagine-32.

***Distant Suns for Windows (CD-ROM version)**, Virtual Reality Laboratories, Inc., 2341 Ganador Court, San Luis Obispo, CA 93401, (805) 545-8515. Price: $149.95. Minimum requirements: 80286-based computer, Windows 3.X, SVGA display, over 5 MB of free space on a hard drive, and a CD-ROM drive.*

The CD-ROM version of Distant Suns contains over 1,500 full-screen images. They include Earth seen from Gemini and Skylab, the planets (including dozens of Voyager images), the Moon from Lunar Orbiter and Apollo, and lots of deep-sky objects. Since we last reviewed Distant Suns (version 1.0 in the April 1992 AstroBytes), changes to the program (now version 1.02) have increased the speed at which the screen updates. Also you can now plot comet and asteroid positions.

***MacStronomy (version 2.0)**, Etlon Software, 1936 Quail Circle, Louisville, CO 80027, (303) 665-3444. Price: $60. Minimum requirements: Macintosh, 2 MB of memory, hard disk, and system 6.0.4. It is System 7 compatible. An optional Mag 8 stellar database (almost 50,000 stars and deep-sky objects) sells for $25. An SAO stellar database (over 250,000 stars) and RNGC deep-sky database (more than 6,000 objects) together cost $50.*

This Mac-based planetarium program displays sky maps showing all stars down to magnitude 6.5, about 1,100 deep-sky objects, the planets, four asteroids, several comets, and the main satellites of Mars, Jupiter, and Saturn. You can add your own objects to the databases. A time-step feature lets you watch eclipses and trace the motions of the planets. You can view the sky from the other planets or display images of the planets taken by NASA space probes. MacStronomy also lets you print star maps to use at your telescope or with your unaided eye.

***Our CosmoHood (version 2.01)**, Bodono Software, 51054 Kingwood, Shelby Township, MI 48316. Price: $25 (shareware). Minimum requirements: IBM PC-compatible, EGA graphics, and a hard disk with 600 KB free space. A mouse and math coprocessor are optional.*

This unique program shows two- and three-dimensional views of our galactic neighborhood. It lets you explore the positions and relationships of 2,368 galaxies within 130 million light-years of our Milky Way Galaxy. A movie sequence slowly steps away from our Galaxy through the Local Group, the Local Association, and the Coma-Sculptor Cloud out to the Local Supercluster. To further explore our parcel of real estate in the universe, you can plot individual views, specifying viewing angle and position. An identification feature names each galaxy and lists its membership in groups and associations.

***Arizona Database (version 8.0)**, Arizona Database, 3131 E. Thunderbird Road #8-130, Phoenix, AZ 85032, (602) 992-2813 (evenings). Price: $89.95 plus shipping and handling; $29.95 plus shipping* *to upgrade from previous versions. Minimum requirements: IBM PC-compatible computer, DOS 3.1, and a hard disk with 13.5 MB of free space.*

This update of the Arizona Database, which comes with AZVUE 5.0 to read and display the database, adds over 16,000 deep-sky objects to the previous database for a total of almost 60,000 objects. The database now includes all the objects from the *Sharpless Catalogue of HII Regions,* Beverly Lynds' *Bright Nebulae Catalogue,* Arp's *Catalogue of Peculiar Galaxies,* Abell's *Southern Galaxy Cluster Catalogue,* and the *Markarian Galaxy Catalogue.* These objects are in addition to all the objects in the *New General Catalogue, Index Catalogues, Messier Catalog, Morphological Catalogue of Galaxies, Catalog of Galactic Planetary Nebulae,* Lund *Catalogue of Open Clusters,* and the *Uppsala General Catalogue of Galaxies.* The producers of this software have corrected known errors in these catalogs.

AZVUE has a new look, using a Windows-like environment. A Help facility helps you maneuver around the program. As before, you can maintain observing notes. A search feature lets you custom design your observing lists. Unlike previous versions, AZVUE 5.0 now displays the visual magnitudes and surface brightnesses of some objects.

Total Eclipse (version 2.0)*, Zephyr Services, 1900 Murray Avenue, Pittsburgh, PA 15217, (800) 533-6666. Price: $129.95 plus $4 for shipping. Minimum requirements: IBM PC-compatible, EGA graphics, and a hard disk.*

Going to the November 1994 total solar eclipse in South America? Check out the path of the eclipse with this program. Or explore any eclipse from 4712 B.C. to A.D. 9999. Total Eclipse will plot world maps that show the centerlines of many solar eclipses at once (like Oppolzer's *Canon der Finsternisse)* as well as regional maps that show the path of the Moon's shadow for a single eclipse. For any location, the software will tell you the eclipse starting and ending times, magnitude of the eclipse, and altitude of the Sun. An animation feature shows what the eclipse will look like.

Total Eclipse will also provide information about lunar eclipses, including start, end, and maximum eclipse times. The program can also plot a map showing where the lunar eclipse is visible. ☐

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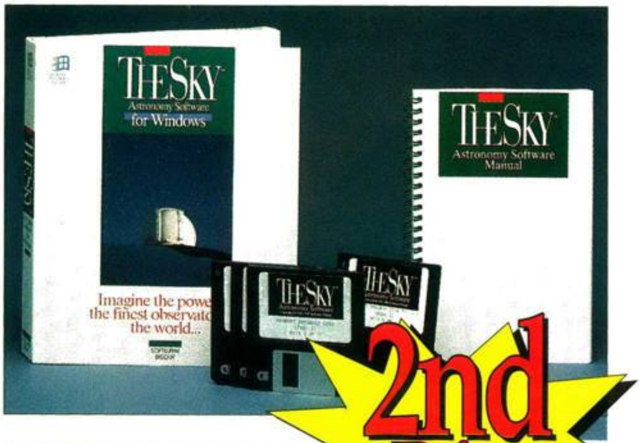

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G. Avenasov and B. Zhukov

MOONS OF MARS Are Phobos and Deimos captured asteroids? Controversy still shrouds the origins of these tiny Martian satellites.

THE STAR THAT BLEW A HOLE IN SPACE Imagine a supernova so close it outshone the Full Moon. Astronomers think such an explosion created the interstellar bubble we live in.

TWO AFFORDABLE TELESCOPES ASTRONOMY tests Orion's new 6- and 8-inch Dobsonians, scopes that won't cost you an arm and a leg.

GEMINIDS TO SHINE Bright streaks of light will pepper the dark skies of mid-December as the Geminid meteor shower peaks.

AVAILABLE ON YOUR NEWSSTAND NOVEMBER 9

Readings & Credits

Intruder Galaxies (page 28)

Galaxies by Timothy Ferris, (Stewart, Tabori, and Chang, 1982). Describes the Local Group and some of our neighboring galaxies.

Where the Lunar Winds Blow Free (page 36)

"A Picture of the Moon's Atmosphere," by Brian Flynn and Michael Mendillo, *Science*, vol. 261, pp. 194-186, 1993. Technical paper reporting on some of the work mentioned in the story.

Lunar Sourcebook by Grant Heiken, David Vaniman, and Bevan French (Cambridge University Press, 1991). A detailed summary of lunar knowledge for the professional scientist; also contains summary chapters fairly accessible to lay readers.

The Moon — Our Sister Planet, by Peter H. Cadogan, (Cambridge University Press, 1981). Contains a short but detailed section on the lunar atmosphere.

Close Encounter with a Comet (page 42)

"ICE: Mission to Comet Giacobini-Zinner," by Richard Berry, ASTRONOMY, December 1985. Here's what the International Cometary Explorer learned during the first flyby of a comet.

"Giotto Encounters Comet Halley," by Richard Berry, ASTRONOMY, June 1986. Before flying past Comet Grigg-Skjellerup, Giotto revealed the nucleus of Comet Halley.

1994 Telescope Buyer's Guide (page 59)

The Backyard Astronomer's Guide, by Terence Dickinson and Alan Dyer, (Camden House, 1991). Contains several chapters about choosing binoculars, telescopes, and telescope accessories.

Build an Observing Chair (page 78)

"Build a Universal Tripod" by M. Leon Knott, ASTRONOMY, August 1992. Describes another way to build a tripod head and leg spreaders.

Eclipse over America (page 82)

When The Moon Disappears, by Alan Dyer and Richard Talcott, ASTRONOMY, December 1992. A preview of last December's total eclipse with extensive tips on photographing lunar eclipses.

Return to Darkness (page 88)

Eclipse Prospects for the 1990s, by Jay Anderson, ASTRONOMY, February 1989. A look ahead to the solar eclipses of the coming decade.

Cover: Roland Christen, 130mm f/8 refractor with radial gradient neutral density filter, Ektar 25 film, 2-second exposure; ***p. 4:*** Jim Barclay; ***p. 20, left:*** Tod R. Lauer (NOAO) and NASA; ***right:*** NASA; ***p. 22:*** NASA; ***p. 24:*** Alan Dyer; ***p. 26, left:*** NASA; ***right:*** © Frank Freas; ***pp. 28-29:*** illustration by Joe Bergeron; ***p. 30:*** Kim Zussman; ***p. 31:*** illustration by Phil Kirchmeier; ***p. 32:*** courtesy of Gerard Luppino; ***pp. 33-35:*** illustrations by Phil Kirchmeier; ***pp. 36-37:*** NASA: ***p. 38:*** Michael Mendillo, Jeffrey Baumgardner, and Brian Flynn/Boston University Center for Space Physics; ***p. 39:*** NASA; ***p. 40:*** NASA; ***p. 41:*** Michael Mendillo, Jeffrey Baumgardner, and Brian Flynn/Boston University Center for Space Physics; ***p. 42:*** R. Birkle; ***pp. 42-43:*** ESA; ***p. 44:*** NASA, courtesy Harold Reitsema and Alan Delamere (Ball Aerospace); ***p. 45:*** ESA; ***p. 46:*** Thomas L. Hunt from material supplied by the University of Kent at Canterbury; ***p. 47:*** University of Kent at Canterbury; ***p. 52:*** Joe Myers; ***p. 53:*** Chick Capen; ***p. 55:*** George Georgiadis; ***p. 57:*** Wanda Walker; ***p. 59, starfield:*** Ronald Royer; ***p. 60:*** illustration by Thomas L. Hunt; ***pp. 61-73:*** equipment photos taken by Darla Evans or supplied by manufacturers; ***p. 78,* left:** Chris Becker; ***right:*** Gerald Wolczanski; ***p. 79:*** James Forbes; ***p. 80:*** Chris Becker and Thomas L. Hunt; ***p. 81:*** illustration by Thomas L. Hunt; ***p. 82:*** Bill and Sally Fletcher; ***pp. 82-83:*** Terence Dickinson; ***p. 84, top:*** Henry N. Lore, 8-inch f/10 SCT, Kodachrome 64 film, 31-second exposure; ***bottom:*** Ronald Royer, 135mm f/11 lens, Ektachrome 64 film; ***p. 85:*** Bill Sterne; ***p. 86, top:*** Benjamin Gomes-Casseres, 200mm lens, Ektachrome 400 film; ***bottom:*** illustration by Thomas L. Hunt after Fred Espenak; ***p. 87:*** Mark Payne-Gill, 12-inch f/5.2 reflector, Fuji 100D film, 15-second exposure; ***p. 88:*** NASA/Alfred McEwen and USGS; ***p. 89:*** Jason Paschal, July 11, 1991, 500mm f/4 lens with 1.4x teleconverter, $^{1}/_{30}$-second, Fujichrome 100; ***p. 90, middle:*** Herb Beebe; bottom: Joel Harris; ***pp. 90-91:*** illustration by Thomas L. Hunt after Jay Anderson and Fred Espenak; ***p. 92:*** Environment Canada; ***p. 93:*** illustration by Thomas L. Hunt after Jay Anderson; ***p. 94, bottom:*** Luke Dodd; ***pp. 94-95:*** John P. Gleason; ***p. 95:*** Luke Dodd; ***p. 96, top:*** Mike Simmons; ***bottom:*** Chuck Vaughn; ***p. 97, top:*** Harvey Freed; ***middle*:** Kim Zussman; ***bottom:*** Martin C. Germano; ***pp. 101, top:*** Christos Frantzolas, 80mm lens at f/1.7, Kodacolor 400 film, 10-minute exposure; ***bottom:*** Edwin Faughn, 13-inch f/4.5 reflector; ***p. 102, top left:*** Joshua T. Vaughan, 28mm lens, 5-minute exposure taken in 1989; ***bottom left:*** Bill and Sally Fletcher, 16-inch f/4.5 reflector, hypersensitized Tech Pan film, tricolor composite image; ***top right:*** Bob Sandy, 55mm lens at f/1.7, Konica 3200 film, 60-second exposure; ***bottom right:*** Milan Kamenicky, 98mm coronagraph at f/37, Kodak film, $^{1}/_{25}$-second exposure on September 6, 1989; ***p. 103:*** Russell Underwood; ***p. 104:*** George Greaney, 5-inch refractor at f/6, Fuji Super HG 400 film, composite of two 50-minute exposures.

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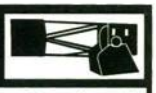

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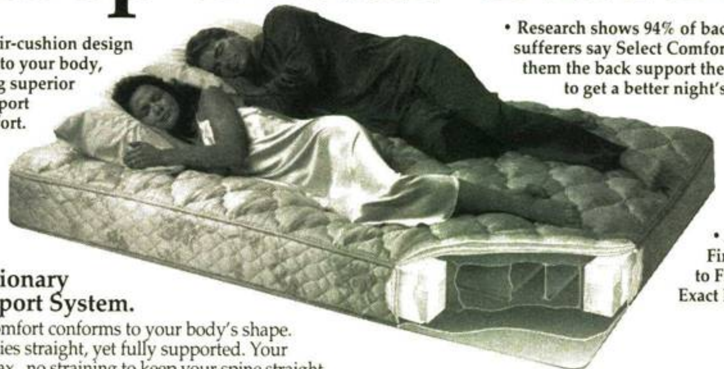

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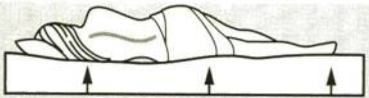

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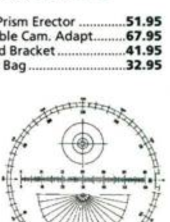

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Meetings & Events

October 12-17

Okie-Tex Star Party, Group Camp 3, Lake Murray, Oklahoma. Sponsored by the Oklahoma City Astronomy Club. Contact Clive or Beryl Cadle, P.O. Box 21221, Oklahoma City, OK 73156, (405) 789-3742.

October 14-17

Chiefland Starfest, Chiefland, Florida. Contact Astro Scopers, Route #1, Box 302-C, Chiefland, FL 32626, Sparky Talios, (904) 493-4359.

October 14-17

11th Annual Deep South Regional Stargaze, Percy Quin State Park (near McComb), Mississippi. Sponsored by the Pontchartrain Astronomy Society, Inc. Contact Barry Simon, 820 Emerald Street, New Orleans, LA 70124, (504) 283-7592.

October 15-16

All-Arizona Star Party, 15 miles south of Arizona City. Contact East Valley Astronomy Club, 1836 N. Stapley Drive #100, Mesa, AZ 85203, Ted Heckens, (602) 827-1524.

October 15-16

Kopernik Astronomy Fest, Kopernik Space Education Center, Vestal, New York. Contact Kopernik Astronomical Society, 698 Underwood Road, NY 13850, Jay Edwards, (607) 748-3685.

October 15-17

15th Annual Astronomy Jamboree, Custer Institute, Southold. Contact Custer Institute Observatory, Box 1204, Main Bayview Road, Southold, NY 11971, Barbara Lebkuecher, (516) 722-3850.

October 15-17

Stella-Della-Valley VII, Camp Onas, Ottsville, Pennsylvania. Sponsored by the Buck-Mont Astronomical Association. Contact Ed Melnick, 1443 Devon Road, Warminster, PA 18974, (215) 443-7929.

October 16

Autumn Star Party, Portsmouth, Virginia. Sponsored by the Tidewater Community College Planetarium Society. Contact R. H. Stewart, 1064 Dune Street, Norfolk, VA 23503.

October 20-23

29th Annual Conference of the Great Lakes Planetarium Association, Dayton Museum of Natural History, Dayton, Ohio. Sponsored by the Great Lakes Planetarium Association. Contact Art Goss, Museum of Natural History, 2600 DeWeese Parkway, Dayton, OH 45414, (513) 275-7431.

October 22-24

2nd Annual Convention of the Antique Telescope Society, George Williams College, adjacent to Yerkes Observatory, Williams Bay, Wisconsin. Sponsored by the Antique Telescope Society. Contact Walter H. Breyer, 30 Green Valley Road, Wallingford, PA 19086.

October 22-24

9th Annual Midwest Space Development Conference, Indianapolis, Indiana. Contact MSDC, 524 West 6th Street, Lakeside, OH 43440-1717.

November 6

Astronomy SwapMeet 1993, Moorpark College, Moorpark, California. Sponsored by the Ventura County Astronomical Society. Contact the Ventura County Astronomical Society, (805) 529-7813 and leave a message.

November 6

4th Annual Optics Workshop, Bellingham, Washington. Sponsored by the Whatcom Association of Celestial Observers. Contact Kreig McBride, 402 E. Horton Road, Bellingham, WA 98226, (206) 671-1665.

November 12-14

2nd Annual Star Party, Lake Kissimmee State Park (15 miles east of Lake Wales), Florida. Contact George Aycrigg, 14248 Camp Mack Road, Lake Wales, FL 33853, (813) 696-1112 evenings.

November 19-20

Fall Spectacular, "The Moon and Saturn," Lemon Lake County Park, Crown Point, Indiana. Sponsored by the Calumet Astronomical Society. Contact Stephen J. Miller, (219) 845-9174.

December 11

3rd Annual ASV Star-Be-Cue, near Melbourne, Australia. Sponsored by the Astronomical Society of Victoria. Contact Perry Vlahos, 103a Orrong Crescent, North Caulfield, Victoria, 3161 Australia, phone (03) 527-8719. ☐

Clubs, please submit announcements at least four months before the date of the meeting or event. Readers, when you write to organizations listed in Meetings and Events, include a self-addressed, legal-sized envelope with your request for information.

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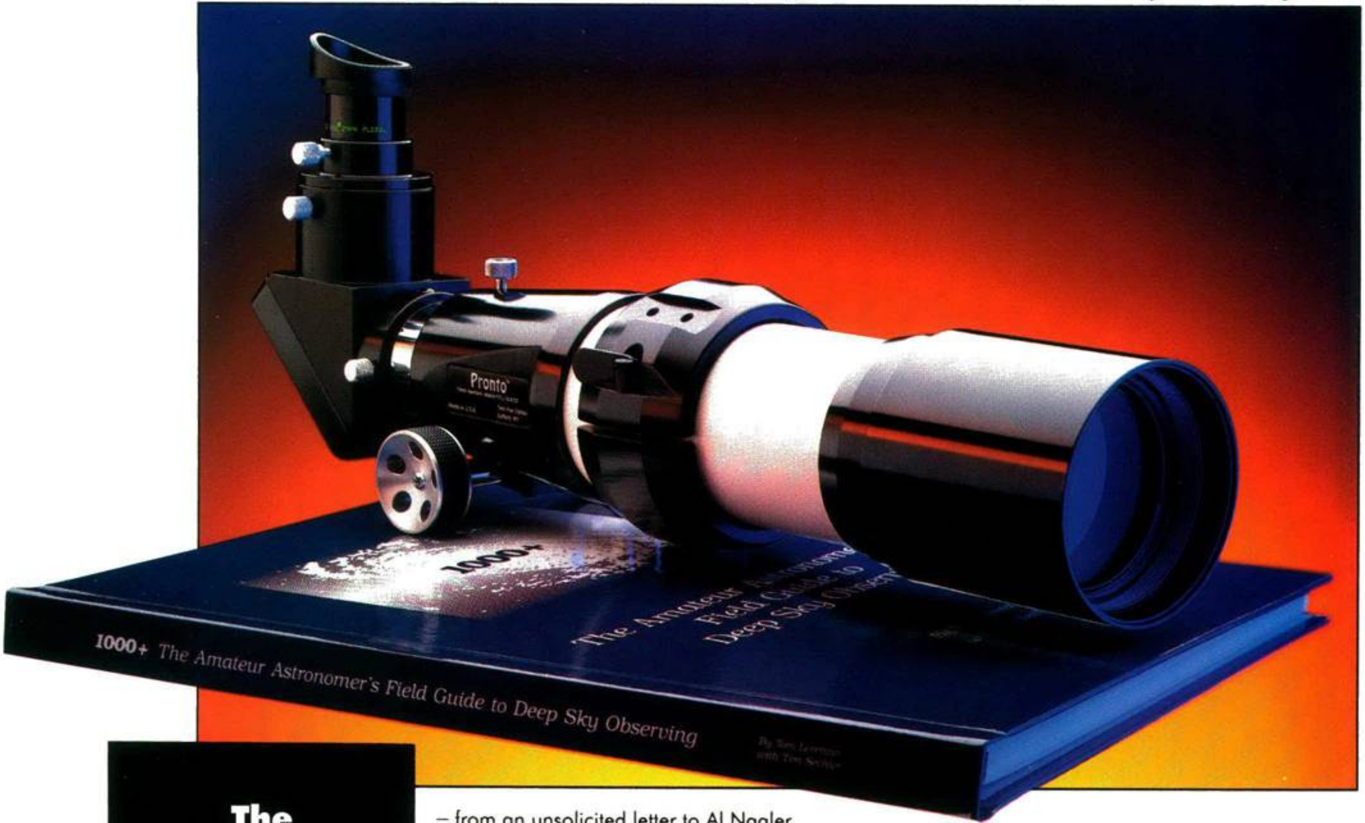
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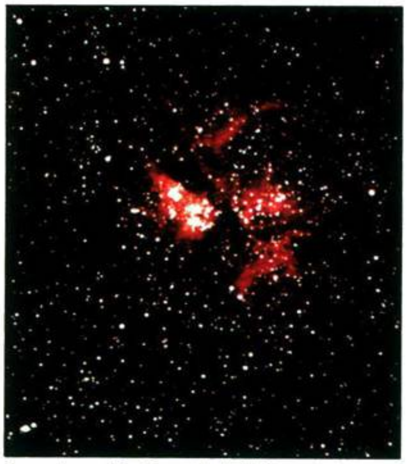
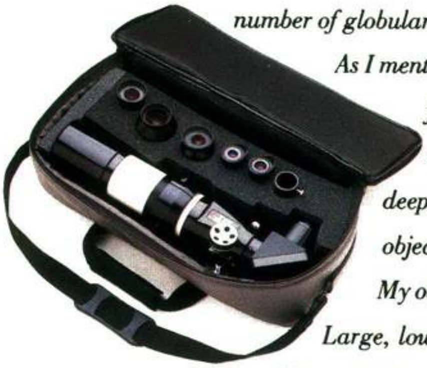
The limiting stellar magnitude is between v=13.5 and v=14.0. This limiting magnitude is faint enough that a substantial number of globular clusters will be at least partially resolved.

As I mentioned before, the 30x eyepiece is my favorite for sweeping the Milky Way. I ended up using 50x for larger objects; 75x for 'ordinary' deep-sky viewing. A few high surface brightness objects were viewed to advantage at 110x, & I used 150x on double stars.

My observations show that from a true-dark site, the telescope is a real performer. Large, low surface brightness objects are routinely visible; even I was surprised by the visibility of NGC 147. Using the stars plotted on Uranometria, I traced the Andromeda galaxy to 4° length on two nights." – Brian Skiff, Author & Astronomer



Pronto photo of Eta Carina by Ralph Sieger



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